8

Cumulative Impacts

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8. CUMULATIVE IMPACTS

The Council on Environmental Quality regulations that implement the procedural provisions of the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 *et seq.*), define a cumulative impact as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions" (40 CFR 1508.7). The term reasonably foreseeable refers to future actions for which there is a reasonable expectation that the action could occur, such as a proposed action under analysis, a project that has already started, or a future action that has obligated funding. Cumulative impacts can result from individually minor but collectively important actions taking place over a period of time. An evaluation of cumulative impacts is necessary to an understanding of the environmental implications of implementing the Proposed Action and is essential to the development of appropriate mitigation measures and the monitoring of their effectiveness.

DOE structured the cumulative impact assessments in this chapter by identifying actions that could have effects that coincided in time and space with the effects from the proposed repository and associated transportation activities. The identification of the relevant actions was based on reviews of resource, policy, development, land-use plans prepared by agencies at all levels of government and from private organizations, other environmental impact statements, environmental assessments, and Native American tribal meeting records. Consistent with Council on Environmental Quality regulations 40 CFR 1502.16(c) and 1506.2, in addition to the assessment of potential cumulative impacts, the analysis considered potential conflicts with plans issued by various governmental entities to the extent practicable and to the extent they provided relevant information.

Not all actions identified in this chapter would have cumulative impacts in all discipline areas. Potential impacts for such actions are discussed for the appropriate discipline areas. In some instances for which an action is reasonably foreseeable, quantitative estimates of impacts are not possible because the action is in its early stages. For those actions, DOE acknowledges the project and states that potential cumulative impacts are unknown at this time.

This chapter evaluates the environmental impacts of repository activities coupled with the impacts of other Federal, non-Federal, and private actions. As part of this process, the chapter includes a detailed analysis of nuclear materials in need of permanent disposal in excess of those evaluated in the Proposed Action. It describes and evaluates these waste quantities, referred to as Inventory Modules 1 and 2, evaluated in terms of their environmental impacts in comparison with those of the Proposed Action impacts. The evaluation of these inventories provides sufficient information for future actions and decisionmaking on inventory selection. This chapter evaluates cumulative short-term impacts from the construction, operation and monitoring, and closure of a geologic repository at Yucca Mountain, and cumulative long-term impacts following repository closure. It also evaluates cumulative transportation impacts from the shipment of spent nuclear fuel and high-level radioactive waste to the repository and of other material to or from the repository. The analysis of cumulative transportation impacts includes the possible construction and operation in Nevada of a branch rail line, or of an intermodal transfer station along with highway improvements for heavy-haul trucks. In addition, the analysis considers cumulative impacts from the manufacturing of repository components.

The cumulative impact analysis in this chapter includes as a reasonably foreseeable future action the disposal in the proposed Yucca Mountain Repository of the total projected inventory of commercial spent nuclear fuel, U.S. Department of Energy (DOE) spent nuclear fuel, and high-level radioactive waste, as well as the disposal of commercial Greater-Than-Class-C waste and DOE Special-Performance-Assessment-Required waste. The total projected inventory of spent nuclear fuel and high-level radioactive waste is more than the 70,000 metric tons of heavy metal (MTHM) considered for the

Proposed Action. Its emplacement at Yucca Mountain would require legislative action by Congress unless a second licensed repository was in operation.

There were several reasons to evaluate the potential for disposing of Greater-Than-Class-C waste and Special-Performance-Assessment-Required waste at Yucca Mountain as reasonably foreseeable actions. First, because both materials exceed Class C limits for specific radionuclide concentrations as defined in 10 CFR Part 61, they are generally unsuitable for near-surface disposal. Second, the U.S. Nuclear Regulatory Commission specifies in 10 CFR 61.55(a)(2)(iv) the disposal of Greater-Than-Class-C waste in a repository unless the Commission approved of disposal elsewhere. Finally, during the scoping process for this environmental impact statement (EIS), several commenters requested that DOE evaluate the disposal of other radioactive waste types that might require isolation in a repository. The disposal of Greater-Than-Class-C and Special-Performance-Assessment-Required wastes at the proposed Yucca Mountain Repository could require a determination by the Nuclear Regulatory Commission that these wastes require permanent isolation. In addition to spent nuclear fuel, high-level radioactive waste, surplus plutonium, Greater-Than-Class-C waste, and Special-Performance-Assessment-Required waste (materials such as depleted uranium), other radioactive wastes could be considered in the future for disposal in the Yucca Mountain Repository.

By analyzing the emplacement of Inventory Module 1 or 2, DOE is not stating that the emplacement of materials beyond those prescribed for the Proposed Action would occur. Rather, the Department is being prudent in analyzing a reasonably foreseeable action that could take place. If a future decision was made to emplace additional material included in the Inventory Modules, the Department would ensure that appropriate National Environmental Policy Act reviews were performed.

In general, the analysis of cumulative impacts in this chapter follows the process recommended in the Council on Environmental Quality's handbook *Considering Cumulative Effects Under the National Environmental Policy Act* (DIRS 103162-CEQ 1997, all). This process includes the identification, through research and consultations, of Federal, non-Federal, and private actions with possible effects that would be coincident with those of the Proposed Action on resources, ecosystems, and human communities. Coincident effects would be possible if the geographic and time boundaries for the effects of the Proposed Action and past, present, and reasonably foreseeable future actions overlapped. Using the methods and criteria described in Chapters 4, 5, and 6 of this EIS and their supporting appendixes, DOE assessed the potential cumulative impacts of coincident effects.

This chapter has six sections. Section 8.1 identifies and analyzes past, present, and reasonably foreseeable future actions with impacts that could combine with impacts of the Proposed Action. Sections 8.2 and 8.3 present the analyses of cumulative short-term (the period before the completion of repository closure) and long-term (the first 10,000 and first 1 million years following closure) impacts, respectively, in the proposed Yucca Mountain Repository region. Section 8.4 describes cumulative transportation impacts, nationally and in Nevada. Section 8.5 addresses cumulative impacts associated with the manufacturing of repository components. Section 8.6 presents an overall summary of potential cumulative impacts by discipline area.

8.1 Past, Present, and Reasonably Foreseeable Future Actions

This section identifies past, present, and reasonably foreseeable future actions with impacts that could combine with impacts of the Proposed Action. It describes these actions and their relationships to the Proposed Action that could result in cumulative impacts (see Table 8-1 for a summary). Sections 8.2 through 8.5 present the cumulative impacts from the past, present, and reasonably foreseeable future actions identified in this section.

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Table 8-1. Past, present, and reasonably foreseeable future actions that could result in cumulative impacts (page 1 of 3).

Name and action description	Potential cumulative impact areas: Short-term (Section 8.2)	Long-term (Section 8.3)	Transportation (Section 8.4)[a]	Manufacturing (Section 8.5)
Past and present actions[b]				
Nevada Test Site				
Nuclear weapons testing, waste management, etc.	Air quality and public health and safety[b]	Air quality, groundwater, and public health and safety	Occupational and public radiological health and safety	None
Beatty Waste Disposal Area				
Low-level radioactive and hazardous waste disposal	None	Groundwater and public health and safety	Occupational and public radiological health and safety	None
Reasonably foreseeable future actions				
Inventory Module 1[c]				
Disposal of all spent nuclear fuel and high-level radioactive waste in the proposed Yucca Mountain Repository	Same resource areas as the Proposed Action (see Table 8-5)	Same resource areas as the Proposed Action (see Table 8-5)	Same resource areas as the Proposed Action (see Table 8-5)	Same resource areas as the Proposed Action (see Table 8-5)
Inventory Module 2[c]				
Disposal of all spent nuclear fuel and high-level radioactive waste, as well as Greater-Than-Class C waste and Special-Performance-Assessment-Required waste, in the proposed Yucca Mountain Repository	Same resource areas as the Proposed Action (see Table 8-5)	Same resource areas as the Proposed Action (see Table 8-5)	Same resource areas as the Proposed Action (see Table 8-5)	Same resource areas as the Proposed Action (see Table 8-5)
Nellis Air Force Range				
National testing and training for military equipment and personnel	None	None	Land use	None
Nevada Test Site				
Defense (stockpile stewardship and management, material disposition, nuclear emergency response), waste management, environmental restoration, nondefense research and development, work for others	Air quality, groundwater, socioeconomics, public health and safety. (Note: The accident analysis of potential external events in Appendix H addresses the effects of possible future resumption of nuclear weapons tests).	Groundwater and public health and safety	Occupational and public radiological health and safety	None
Nevada Test Site				
Alternative Energy Generation Facility	*Land use, utilities*	None	None	None
DOE Complex-Wide Waste Management Activities Affecting the Nevada Test Site				
Treatment, storage, and disposal of low-level radioactive waste, mixed waste, transuranic waste, high-level radioactive waste, and hazardous waste from past and future nuclear defense and research activities	No additional[d] beyond those analyzed for Nevada Test Site activities	Groundwater and public health and safety	Occupational and public radiological health and safety	None

Table 8-1. Past, present, and reasonably foreseeable future actions that could result in cumulative impacts (page 2 of 3).

Name and action description	Potential cumulative impact areas: Short-term (Section 8.2)	Long-term (Section 8.3)	Transportation (Section 8.4)[a]	Manufacturing (Section 8.5)
Reasonably foreseeable future actions (continued)				
Low-Level Waste Intermodal Transfer Station				
Construction and operation of an intermodal transfer station for the shipment of low-level radioactive waste to the Nevada Test Site near Caliente	None	None	Same resource areas as the Proposed Action (see Table 8-5) (Caliente intermodal transfer station and highway route for heavy-haul trucks)	None
Timbisha Shoshone Reservation				
Creation and development of a discontiguous reservation in eastern California and southwestern Nevada	Land use, groundwater	None	Water consumption, land use, public safety, environmental justice	None
Cortez Pipeline Gold Deposit Projects				
Continued operation and potential expansion of a gold mine and processing facility	None	None	Land use and ownership (Carlin rail corridor)	None
Apex Bulk Commodities Intermodal Transfer Station				
Construction and operation of an intermodal transfer station for copper concentrate near Caliente	None	None	Same resource areas as the Proposed Action (see Table 8-5) (Caliente intermodal transfer station and highway route for heavy-haul trucks)	None
Shared use of a DOE branch rail line				
Increase in rail operations and traffic resulting from rail service options for nearby mine operators and communities	None	None	Same resource areas as the Proposed Action (see Table 8-5)	None
Private Fuel Storage				
Temporary storage of spent nuclear fuel at the Goshute Reservation in Utah	None	None	Occupational and public radiological health and safety	None
Owl Creek Energy Project				
Temporary storage of spent nuclear fuel	None	None	Potential occupational and public radiological health and safety	None
Ivanpah Airport				
Construction of an airport on previously undisturbed land	None	None	Land use (Jean transportation corridor)	None
Moapa Paiute Energy Center				
Lease land and water use for construction of a coal-fired powerplant	None	None	Land use	None

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Table 8-1. Past, present, and reasonably foreseeable future actions that could result in cumulative impacts (page 3 of 3).

Name and action description	Potential cumulative impact areas: Short-term (Section 8.2)	Long-term (Section 8.3)	Transportation (Section 8.4)[a]	Manufacturing (Section 8.5)
Reasonably foreseeable future actions (continued)				
Southern Nevada Public Land Management Act				
Convey approximately 110 square kilometers[e] of Bureau of Land Management lands to commercial and private entities	Land use and ownership	None	Land use and ownership	None
Desert Space Station Science Museum				
Construct an 8,800-square-meter[f] science museum on land acquired from the Bureau of Land Management	Land use	None	None	None

a. In addition to the specific actions identified in Section 8.1 and summarized in this table, the cumulative impacts for national transportation consider the occupational and public radiological health impacts of other past, present, and reasonably foreseeable future shipments of radioactive material.
b. The impacts of most past and present actions are included in the existing environmental baseline described in Chapter 3 and, therefore, are generally encompassed in the analysis of potential impacts of the Proposed Action in Chapters 4, 5, and 6. This includes site characterization activities at Yucca Mountain.
c. As described in Section 8.1.2.1, there would be essentially no difference in the design and operation of the repository for Inventory Module 1 or 2. Therefore, the cumulative impacts from Inventory Module 1 are generally considered the same as those from Inventory Module 2.
d. DOE waste management activities at the Nevada Test Site are included for the continuation of waste management activities at current levels, plus additional wastes that could be received as a result of decisions based on the Waste Management Programmatic EIS (DIRS 101816-DOE 1997, all). This includes cumulative impacts of transportation and disposal.
e. 110 square kilometers = 27,000 acres.
f. 8,800 square meters = 95,000 square feet.

8.1.1 PAST AND PRESENT ACTIONS

The description of existing (baseline) environmental conditions in Chapter 3 includes the impacts of most past and present actions on the environment that the Proposed Action would affect. This includes site characterization activities at Yucca Mountain. The impacts of past and present actions are, therefore, generally encompassed in the Chapter 4, 5, and 6 analyses of potential environmental impacts of the Proposed Action because the baseline for these analyses is the affected environment described in Chapter 3.

Two past actions that are not addressed in the Chapter 3 environmental baseline were identified for inclusion in the cumulative impact analysis in Sections 8.2, 8.3, and 8.4—past DOE activities at the Nevada Test Site (nuclear weapons testing, etc.) and past disposal of low-level radioactive waste at the Beatty Waste Disposal Area. Resources identified where past Nevada Test Site activities could add to impacts from the Proposed Action include air quality, groundwater, public health and safety, and transportation. For the Beatty Waste Disposal Site, the analysis included potential cumulative impacts from past transportation of waste to the Beatty site and from potential groundwater contamination.

Other actions that are presently occurring also have a component that is reasonably foreseeable as a future action. These are discussed in Section 8.1.2.

8.1.2 REASONABLY FORESEEABLE FUTURE ACTIONS

This section describes the reasonably foreseeable future actions that the cumulative impacts analysis considered. The analysis included cumulative impacts from the disposal in the proposed repository of all projected spent nuclear fuel and high-level radioactive waste as well as Greater-Than-Class-C waste and Special-Performance-Assessment-Required waste as reasonably foreseeable future actions (Inventory Modules 1 and 2; see Section 8.1.2.1). Sections 8.1.2.2 and 8.1.2.3 describe other Federal, non-Federal, and private actions that could result in cumulative impacts. This chapter does not discuss cumulative impacts for the No-Action Alternative. Chapter 7, Section 7.3, describes those impacts. Chapters 2 and 7 contain details on the No-Action Alternative and on continued storage of the material at its current locations or at one or more centralized location(s).

DOE gathered information on Federal, non-Federal, and private actions to identify reasonably foreseeable future actions that could combine with the Proposed Action to produce cumulative impacts. The types of documents reviewed included other EISs, resource management plans, environmental assessments, Notices of Intent, Records of Decision, etc. Consultations with Federal agencies, state and local agencies, and Native American tribes (see Appendix C) also contributed to the information used in the cumulative impact analysis.

8.1.2.1 Inventory Modules 1 and 2

Under the Proposed Action, DOE would emplace in the proposed Yucca Mountain Repository as much as 70,000 MTHM of spent nuclear fuel and high-level radioactive waste. Of the 70,000 MTHM, approximately 63,000 MTHM would be commercial spent nuclear fuel. The remaining 7,000 MTHM would consist of approximately 2,333 MTHM of DOE spent nuclear fuel and approximately 8,315 canisters (4,667 MTHM) containing solidified high-level radioactive waste (commercial and defense-related). To determine the number of canisters of high-level radioactive waste included in the Proposed Action waste inventory, DOE used an equivalence of 2.3 MTHM per canister of commercial high-level radioactive waste and 0.5 MTHM per canister of defense high-level radioactive waste as discussed in Appendix A, Section A.2.3.1. DOE has consistently used the 0.5-MTHM-per-canister equivalence since 1985. Using a different approach would change the number of canisters of high-level radioactive waste analyzed for the Proposed Action. Regardless of the number of canisters, the impacts from the entire inventory of high-level radioactive waste are analyzed in this chapter. In addition, the 70,000 MTHM inventory would include an amount of surplus plutonium as spent mixed-oxide fuel or immobilized plutonium.

Inventory Modules 1 and 2 represent the reasonably foreseeable future actions of disposing of all projected commercial and DOE spent nuclear fuel and all high-level radioactive waste as well as Greater-Than-Class-C waste and Special-Performance-Assessment-Required waste in the proposed repository (see Figure 8-1). Under Inventory Module 1, DOE would emplace all projected commercial spent nuclear fuel (about 105,000 MTHM), all DOE spent nuclear fuel (about 2,500 MTHM), and all high-level radioactive waste (approximately 22,280 canisters). Inventory Module 2 includes the Module 1 inventory plus other radioactive material that could require disposal in a monitored geologic repository (commercial Greater-Than-Class-C waste and DOE Special-Performance-Assessment-Required waste). The estimated quantities of these other wastes are about 2,000 cubic meters (71,000 cubic feet) and about 4,000 cubic meters (140,000 cubic feet), respectively. Appendix A contains further details on these inventories.

The following paragraphs summarize the differences in repository facilities and operations to receive, package, and emplace the additional materials in Inventory Module 1 or 2. The information on Modules 1 and 2 in this section is from CRWMS M&O (DIRS 104508-1999, DIRS 104523-1999, and DIRS 102030-1999) unless otherwise noted. Table 8-2 summarizes the increased number of shipments that would be required to transport the Module 1 or 2 inventory to the repository. As for the Proposed Action, the estimated numbers of shipments were based on the characteristics of the materials, shipping capabilities at the commercial nuclear sites and DOE facilities, the assumption that there would be one shipping cask per truck or railcar (a train would normally use multiple rail cars and ship more than one

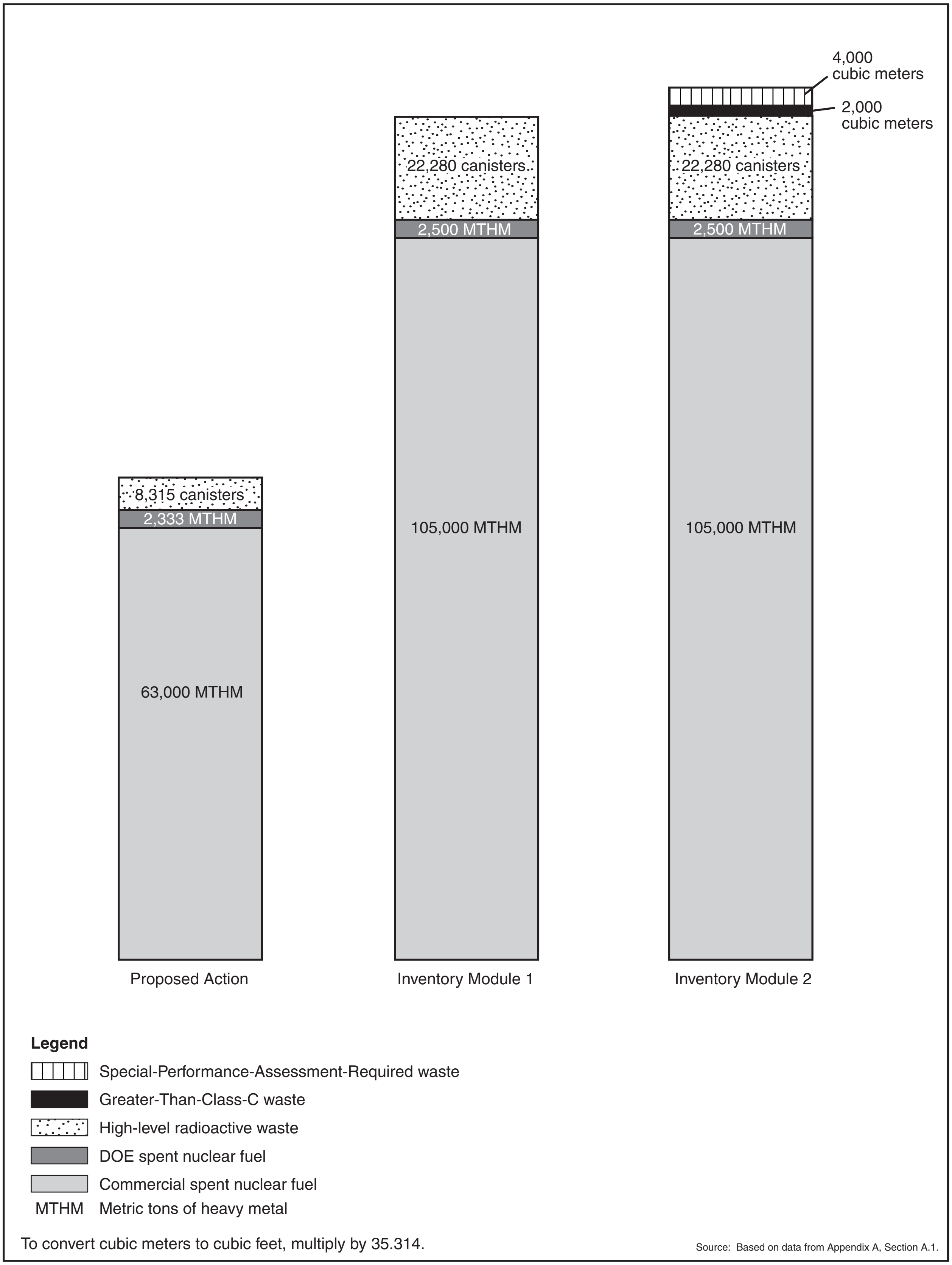

Figure 8-1. Proposed Action, Module 1, and Module 2 inventories evaluated for emplacement in a repository at Yucca Mountain.

Table 8-2. Estimated number of shipments for the Proposed Action and Inventory Modules 1 and 2.[a,b]

	Proposed Action				Module 1				Module 2			
	Mostly legal-weight truck		Mostly rail		Mostly legal-weight truck		Mostly rail		Mostly legal-weight truck		Mostly rail	
Material	Truck	Rail[c]	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail	Truck	Rail
Commercial SNF[d]	41,000	0	1,100	7,200	80,000	0	3,100	13,000	80,000	0	3,100	13,000
DOE SNF	3,500	300	0	770	3,700	300	0	800	3,700	300	0	800
HLW[e]	8,300	0	0	1,700	22,000	0	0	4,500	22,000	0	0	4,500
GTCC[f] waste	0	0	0	0	0	0	0	0	1,100	0	0	280
SPAR[g] waste	0	0	0	0	0	0	0	0	1,800	55	0	410
Totals	***53,000***	***300***	***1,100***	***9,700***	***110,000***	***300***	***3,100***	***18,000***	***109,000***	***360***	***3,100***	***19,000***

a. Source: Appendix J, Section J.1.3.1.
b. Totals might differ from sums of values due to rounding.
c. For this EIS, each combination of a shipping cask and railcar is assumed to be a single shipment.
d. SNF = spent nuclear fuel.
e. HLW = high-level radioactive waste.
f. GTCC = Greater-Than-Class-C.
g. SPAR = Special-Performance-Assessment-Required.

cask), various cask designs, and the transportation mode mix (mostly legal-weight truck or mostly rail). Appendix J contains additional details on Inventory Module 1 and 2 transportation requirements.

The following are the major differences between the repository facilities and operations for Inventory Modules 1 and 2 and those for the Proposed Action, which are described in Chapter 2:

- The longer time required to receive, package, and emplace the additional spent nuclear fuel, high-level radioactive waste, Greater-Than-Class-C waste, and Special-Performance-Assessment-Required waste, and to close the repository, for Inventory Module 1 or 2 versus that for the Proposed Action. The periods for the various project phases for Inventory Modules 1 and 2 would be the same.

- The need for more subsurface area to emplace about 17,000 to 26,000 waste packages for the Inventory Modules in comparison to about 11,000 to 17,000 waste packages for the Proposed Action.

Table 8-3 lists the differences in the expected time sequence for the repository construction, operation and monitoring, and closure phases for the Proposed Action and the Inventory Modules. DOE expects the construction phase to last for 5 years. Following this phase, repository development is projected to last for 22 years and emplacement for 24 years for the Proposed Action. During the operation and monitoring phase, development and emplacement is expected to last for 36 and 38 years, respectively, for Module 1 or Module 2. Monitoring activities during this phase would occur concurrently and then would extend beyond the emplacement period for up to 300 years. DOE expects the closure phase to last between 10 and 17 years for the Proposed Action and between 12 and 23 years for the Inventory Modules.

Table 8-3. Expected time sequence (years) of Yucca Mountain Repository phases for the Proposed Action and Inventory Module 1 or 2.

		Operation and monitoring phase			
Inventory	Construction phase	Development	Emplacement[a]	Monitoring	Closure phase
Proposed Action	5	22	24 - 50	76 - 300	10 - 17
Module 1 or 2	5	36	38 - 51	62 - 300	12 - 23

a. Range results from consideration of various operating modes with and without aging.

The amount of land required for surface facilities would increase only slightly for Inventory Module 1 or 2 from that for the Proposed Action (see Table 8-4). The design and operation of the repository surface facilities for Inventory Modules 1 and 2, including a Cask Maintenance Facility if it was at the Yucca Mountain site, would not differ much from those of the Proposed Action. The rate of material receipt,

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Table 8-4. Amount of land (in square kilometers) newly disturbed at the proposed Yucca Mountain Repository for the Proposed Action and Inventory Module 1 or 2.[a,b,c]

	Proposed Action		Module 1 or 2	
Area	Higher-temperature	Lower-temperature	Higher-temperature	Lower-temperature
North Portal Operations Area	0.62	0.62	0.62	0.62
South Portal Development Area	0.15	0.15	0.15	0.15
Ventilation Shaft Operations Areas and access roads	0.83 (7 shafts)	1.04 - 1.42 (10 - 17 shafts)	1.13 (11 shafts)	1.38 - 1.89 (16 - 25 shafts)
Excavated rock storage area	0.87	0.87 - 1.51	1.40	1.40 - 2.02
Landfill	0.04	0.04 - 0.06	0.04	0.04 - 0.06
Solar power generating facility	0.22	0.22	0.22	0.22
Concrete batch plant	0.06	0.06	0.06	0.06
Surface aging facility	0	0 - 0.47	0	0 - 0.47
Totals	***2.8***	***3.0 - 4.5***	***3.6***	***3.9 - 5.5***

a. Source: DIRS 152010-CRWMS M&O (2000, Table 6-2, p. 52); DIRS 150941-CRWMS M&O (2000, p. 4-9 and Figure 6-1, p. 6-27); DIRS 155515-Williams (2001, 2.1-m Spacing Option: p. 27 and 29; 6.4-m Spacing Option: p. 24); DIRS 155516-Williams (2001, p. 3); DIRS 153882-Griffith (2001, p. 8).

b. To convert square kilometers to acres, multiply by 247.1.

c. Totals might differ from sums of values due to rounding.

packaging, and emplacement would be approximately the same and would require an extra 14 years beyond the 24-year emplacement period for the Proposed Action. There would be no difference in the duration of the emplacement period between Inventory Modules 1 and 2 because the surface and subsurface facilities could accommodate the small number of additional shipments and waste packages for Module 2.

The repository subsurface facilities for Inventory Module 1 or 2 would require about 60 percent more subsurface excavation than the Proposed Action. About 7.2 square kilometers (1,790 acres) would be required for the higher-temperature repository operating mode for Module 1 or 2, and from 10 to 15.4 square kilometers (2,480 to 3,810 acres) for the lower-temperature mode for Module 1 or 2. This compares to about 4.6 square kilometers (1,150 acres) and from 6.5 to 10.4 square kilometers (1,600 to 2,570 acres) for the higher- and lower-temperature modes, respectively, for the Proposed Action. Additional subsurface area would be needed if maximum spacing was used to achieve the lower-temperature mode. DOE would characterize this additional subsurface area, which would be adjacent to the blocks identified for the Proposed Action, more fully before its use. The subsurface facilities would not differ between Inventory Modules 1 and 2 for the lower-temperature operating mode with maximum-spacing because DOE would place the additional waste packages for Greater-Than-Class C and Special-Performance-Assessment-Required wastes between commercial spent nuclear fuel waste packages. However, total drift length would have to be increased by an estimated 3.7 to 4.9 kilometers (2.3 to 3.0 miles) for the other methods to achieve the lower-temperature operating mode when going from Inventory Module 1 to Module 2. There would be no difference in emplacement operating for Inventory Module 1 or 2 from those described for the Proposed Action in Chapter 2 unless DOE used the lower-temperature mode with surface aging. Because of the extra time involved in receiving and emplacing the Module 1 or 2 waste, there would be no delay in the process with the aging option before movement of the aged waste to the subsurface could begin, and DOE could move it at a faster rate. Monitoring and maintenance activities for Inventory Module 1 or 2 would be comparable to those for the Proposed Action with the exception of their duration in some cases.

Because there would be an increase in the number of waste packages and the increased length of the drifts that would be necessary for Inventory Module 1 or 2, the duration of the closure phase would be longer for Module 1 or 2 (12 to 23 years) compared to 10 to 17 years for the Proposed Action (see Table 8-3).

Inventory Module 1 or 2 closure phase activities would not otherwise differ from those described in Chapter 2 for the Proposed Action.

As discussed in the introduction to this chapter, the Department is not proposing at this time to emplace the additional materials from the Inventory Modules in the repository. If a future proposal was made to emplace these materials, the Department would ensure that appropriate National Environmental Policy Act reviews were performed.

8.1.2.2 Federal Actions

The following paragraphs describe reasonably foreseeable future actions of Federal agencies that could result in cumulative impacts in addition to those from Inventory Module 1 or 2.

Nellis Air Force Range

The Nellis Air Force Range (also referred to as the Nevada Test and Training Range) in south-central Nevada (see Figure 8-2) is a national test and training facility for military equipment and personnel. The *Renewal of the Nellis Air Force Range Land Withdrawal: Legislative Environmental Impact Statement* (DIRS 103472-USAF 1999, all) addresses the potential environmental consequences of the Air Force proposal to continue the Nellis Air Force Range land withdrawal for military use. As part of the actions analyzed in the Legislative EIS, the Air Force would renew its land withdrawal of almost 3 million acres and transfer responsibility to DOE for approximately 127,620 acres of land generally described as Pahute Mesa. Figures 8-2 and 8-3 show Pahute Mesa as part of the Nevada Test Site. The President signed S.1059 in October 1999, making it Public Law 106-65 and authorizing the renewed withdrawals and transfers described in the Legislative EIS.

The Air Force also issued the *Final Environmental Impact Statement F-22 Aircraft Force Development Evaluation and Weapons School Beddown at Nellis Air Force Base* in 1999 (DIRS 155928-Estrada 2001, all) to evaluate the potential impacts of locating F-22 aircraft at the Nellis Air Force Range. The action would entail the construction of some new facilities and other modifications to support the aircraft. The Record of Decision (DIRS 155918-Keck 1999, all) shows that the action "would result in either negligible effects or would not change current environmental conditions at Nellis AFB" for the major discipline areas. Therefore, DOE has not quantified potential cumulative impacts from this action. The descriptions of the affected environment in Chapter 3 and the potential impacts of the Proposed Action in Chapters 4, 5, and 6 include the effects of present activities at the Nellis Air Force Range.

Nevada Test Site

Several actions at the Nevada Test Site would pose a cumulative impact. Figure 8-3 shows a map of the Nevada Test Site to assist in identifying the location of these actions.

The *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DIRS 101811-DOE 1996, all) examines current and future DOE activities in southern Nevada at the Nevada Test Site, Tonopah Test Range, and sites the Department formerly operated in Nevada. The first Record of Decision for that EIS (61 *FR* 65551, December 13, 1996) states that DOE would implement a combination of three alternatives: Expanded Use, No Action (continue operations at current levels) regarding mixed and low-level radioactive waste management, and Alternate Use of Withdrawn Lands regarding public education. On February 18, 2000, the Department issued an Amendment of the Record of Decision (65 *FR* 10061, February 26, 2000). In this Amendment, DOE decided, based on its National Environmental Policy Act reviews for the Nevada Test Site and for the Complex-wide waste management program described in the Programmatic Waste Management EIS (DIRS 101816-DOE 1997, all), to implement the Expanded Use Alternative for waste management activities at the Test Site, including mixed and low-level radioactive waste.

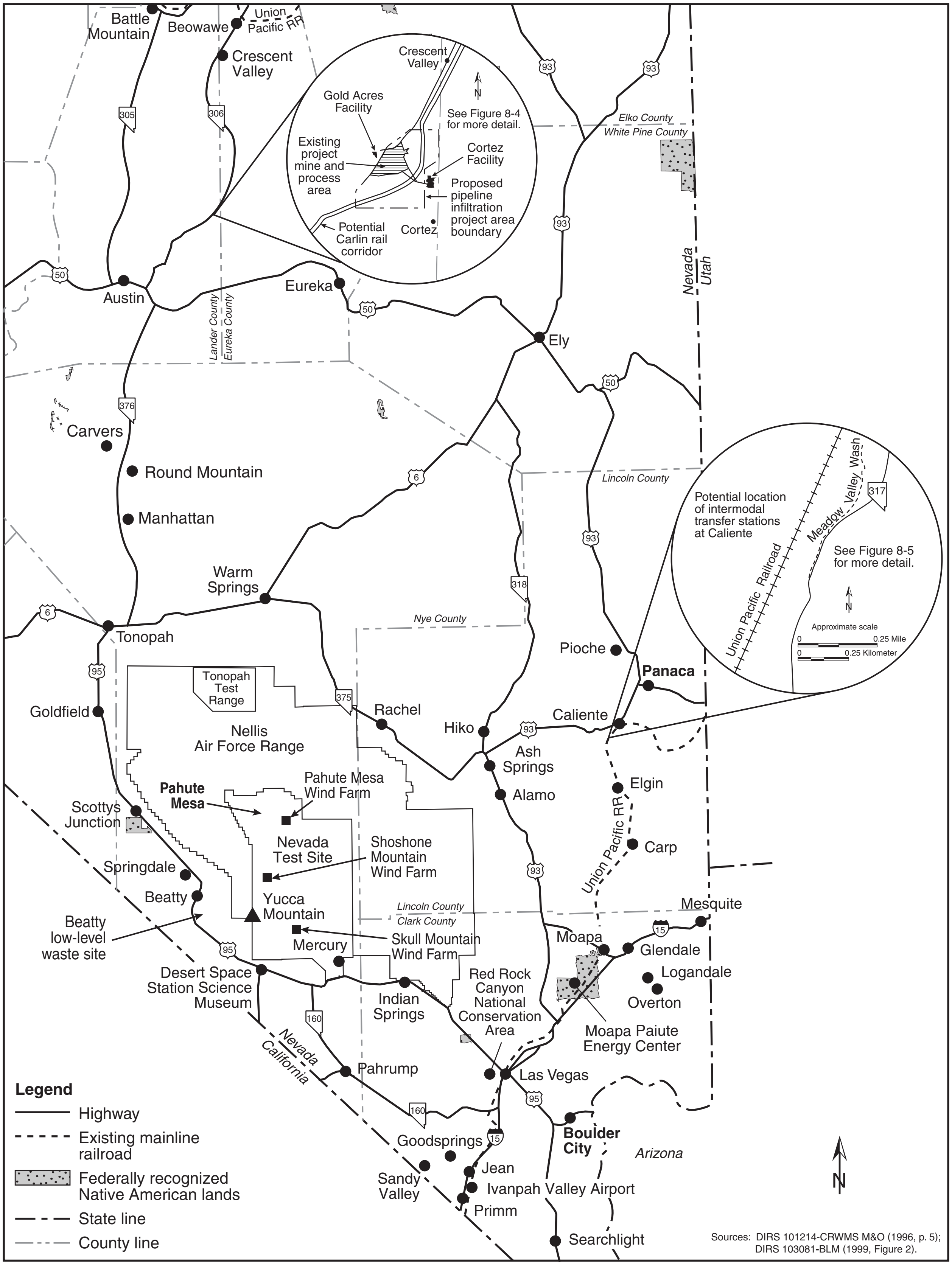

Figure 8-2. Locations of past, present, and reasonably forseeable future actions considered in the cumulative impact analysis.

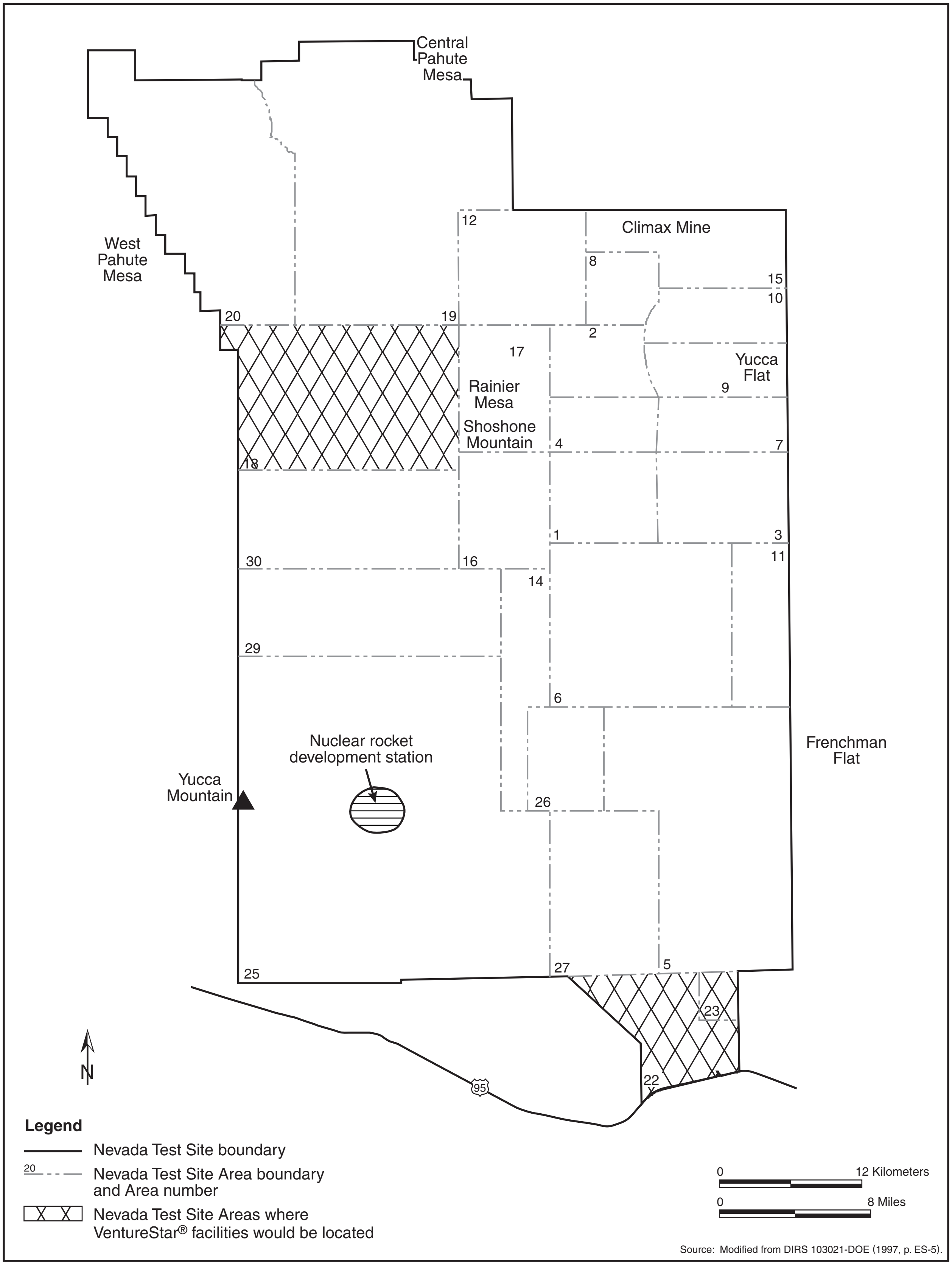

Figure 8-3. Potential locations of proposed cumulative activity associated with VentureStar®/Kistler at the Nevada Test Site.

The Expanded Use Alternative incorporates all the activities and operations from ongoing Nevada Test Site programs and increases some of those programs. Activities of the Office of Defense Programs would expand at both the Nevada Test Site and the Tonopah Test Range, primarily in the areas of stockpile stewardship and management, materials disposition, and nuclear emergency response. As part of the Stockpile Stewardship and Management Program, there are continuing *subcritical* weapons test activities to study aging of weapons components and their reliability after aging. Waste management activities would continue at current levels pending decisions by DOE based on the *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (DIRS 101816-DOE 1997, all). Based on the preferred alternative in the programmatic EIS, this cumulative impact analysis included the additional low-level and mixed waste that could come to the Nevada Test Site. The Environmental Restoration Program would continue, potentially at an accelerated rate, at the Nevada Test Site and all offsite locations. Under the Work for Others Program, military use of the airspace over the Nevada Test Site and the Tonopah Test Range would increase, as would the use of certain lands on the Nevada Test Site by the military for training, research, and development. Public education activities would include the possible construction of a museum that highlights Nevada Test Site testing activities. The Nevada Test Site Development Corporation is considering the VentureStar® program initiative from the Lockheed Martin Corporation for a launch/recovery system that would link with the Kistler Aerospace Satellite launch and recovery project. The VentureStar® program would require two spaceports, a manufacturing and assembly facility, and a payload processing and administrative complex. These activities could occur in Areas 18, 22, and 23, respectively (Figure 8-3). However, the Kistler aerospace activity is currently on hold (DIRS 152582-Davis 2000, all), and there is not enough information at this time to perform a cumulative impacts analysis for this project.

An analysis of the environmental impacts presented in the Nevada Test Site EIS (DIRS 101811-DOE 1996, all) (including impacts from weapons testing and the VentureStar®/Kistler project) identified the following resources for which impacts could overlap in relation to geography and timing with impacts from the proposed repository: air quality, groundwater, socioeconomics, public health and safety, and transportation. The effects on the Yucca Mountain Repository if a decision were made in the future to resume nuclear weapons testing or from a possible vehicle launch or recovery accident at the proposed VentureStar®/Kistler project are considered in the accident analysis of potential external events in Appendix H.

As discussed above in the section on the Nellis Air Force Range, part of the land previously assigned to the Range, specifically the parcel known as Pahute Mesa, has been transferred to the Nevada Test Site. The use of the land has not changed; this was a transfer of jurisdiction to match actual use with ownership.

A moratorium on the explosive testing of nuclear weapons began in October 1992. As discussed in the Nevada Test Site EIS, however, other testing continues at the Test Site, including dynamic, hydrodynamic, and explosive tests (DIRS 101811-DOE 1996, all). These tests are necessary for the continued assurance of the Nation’s nuclear arsenal but do not result in nuclear explosions like those that were common during the Cold War. Therefore, environmental contamination from nuclear weapons testing is largely due to past testing and not to current activities at the Test Site. Although there are potential past and present impacts of the explosive testing of nuclear weapons, the long-lived radionuclides that have been deposited far underground could pose future impacts that are evaluated in Section 8.3. As shown in that section, DOE has made conservative assumptions to ensure the identification of any potential cumulative impacts between the Nevada Test Site and the proposed repository.

In March 2000, DOE published the *Nevada Test Site Development Corporation’s Desert Rock Sky Park at the Nevada Test Site Environmental Assessment* (DIRS 155529-DOE 2000, all) and the associated

Finding of No Significant Impact. This environmental assessment evaluated the potential impacts of issuing a general use permit to the Nevada Test Site Development Corporation to develop, operate, and maintain a commercial/industrial park at the Test Site. The project would permit development of approximately 2 square kilometers (510 acres) of land already designated as a "private/commercial development zone."

In March 2001, DOE published the *Preapproval Draft Environmental Assessment for a Proposed Alternative Energy Generation Facility at the Nevada Test Site* (DIRS 154545-DOE 2001, all). The NTS Development Corporation (NTSDC) and the M&N Wind Power Inc. and Siemens (MNS) have requested authorization (under an easement between DOE and NTSDC and a subeasement between NTSDC and MNS) for the installation of 260 and 436 megawatts of a commercial wind-turbine-generated power system using as many as 545 wind turbine generators on three areas of the Nevada Test Site. The development of this system would allow for land use diversification of the Test Site by including nondefense and private use. The areas consist of the Shoshone Mountain Area, the Pahute Mesa, and Skull Mountain. DOE used these areas comprising 4.9 square kilometers (1,200 acres) for nuclear and conventional explosive testing facilities. The wind generators would be constructed on the ridges in these areas to maximize the effects of wind currents. They would be constructed in three phases and would not conflict with continued Nevada Test Site operations in the valley areas. On July 25, 2001, DOE announced its intention to prepare an EIS based on its analysis contained in the previous environmental assessment. This EIS would consider alternative locations and examine the impacts of the No-Action Alternative.

DOE Waste Management Activities

The Waste Management Programmatic EIS (DIRS 101816-DOE 1997, all) evaluates the environmental impacts of managing five types of radioactive and hazardous wastes generated by past and future nuclear defense and research activities at a variety of DOE sites in the United States. The five waste types are low-level radioactive waste, mixed low-level waste (referred to in this EIS as simply mixed waste), transuranic waste, high-level radioactive waste, and hazardous waste. The Waste Management Programmatic EIS provides information to assist DOE with decisions on the management of, and facilities for, the treatment, storage, and disposal of these radioactive, hazardous, and mixed wastes.

DOE has issued six Records of Decision or revisions to Records of Decision on the Programmatic Waste Management EIS (DIRS 101816-DOE 1997, all). The discussion of these decisions is presented in this section; however, the impacts of actions from these decisions would be related primarily to transportation of materials; these impacts are part of the analysis in Section 8.4. The first Record of Decision (63 *FR* 3629, January 23, 1998) announced the Department's decision to treat and store transuranic waste at each DOE facility except Sandia National Laboratory, which would transfer its transuranic waste to Los Alamos National Laboratory for preparation and storage. This waste would ultimately be disposed of in the Waste Isolation Pilot Plant in Carlsbad, New Mexico.

The fourth Record of Decision announced the Department's decision to make the Nevada Test Site and the Hanford Site available to all DOE sites for disposal of low-level waste and mixed low-level waste. This decision was accompanied by an amendment to the Record of Decision for the Nevada Test Site EIS (65 *FR* 10061, February 25, 2000) to implement the Expanded Use Alternative from that EIS.

On December 29, 2000, the Department announced a revision (65 *FR* 82985) to its decision regarding transuranic waste. Under this decision, the Department would establish at the Waste Isolation Pilot Plant the capability to prepare transuranic waste for disposal. In addition, the above-ground capacity at the Waste Isolation Pilot Plant would be increased by 25 percent.

On July 25, 2001, the Department issued (66 *FR* 38646) a further revision to its previous decision by announcing its decision to transfer about 300 cubic meters of transuranic waste from the Mound facility

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in Miamisburg, Ohio, to the Savannah River Site for storage, characterization, and repackaging prior to sending it to the Waste Isolation Pilot Plant.

The *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* (DIRS 101814-DOE 1997, Chapter 5) identifies potential cumulative transportation impacts from the shipment of transuranic wastes from DOE sites across the United States, including the Nevada Test Site, to the Waste Isolation Pilot Plant in southeastern New Mexico for disposal.

Low-Level Waste Intermodal Transfer Station

DOE prepared a draft environmental assessment (DIRS 103225-DOE 1998, all) on a proposed action to encourage low-level radioactive waste generators and their contractors to use transportation alternatives that would minimize radiological risk, enhance safety, and reduce the cost of waste shipments to the Nevada Test Site. However, DOE determined that there was no decision for it to make relative to transportation of low-level radioactive waste that would require a National Environmental Policy Act analysis, and therefore no longer plans to issue a National Environmental Policy Act document. DOE has published a technical report that provides its low-level radioactive waste generators with a comparative risk analysis of alternative highway routes and intermodal transportation facilities (DIRS 155779-DOE 1999, all).

Road improvements to accommodate legal-weight trucks and the construction of a rail siding or spur on a 0.02-square-kilometer (5-acre) site 1.2 kilometers (0.75 mile) south of Caliente would be needed for the low-level radioactive waste intermodal transfer station. Lifting equipment (crane or forklift) would transfer containers of low-level radioactive waste from railcars to trucks for transport to the Nevada Test Site. Based on a 10-year average estimate of low-level waste volumes and shipments for the expanded use alternative from the Nevada Test Site EIS (DIRS 101811-DOE 1996, pp. 5-110 to 5-112), DOE expects the traffic through the intermodal transfer station to be less than 3 trains per day and about 14 trucks per day (7 outbound from the station and 7 returning from the Nevada Test Site). Intermodal transfer operations would occur only during daytime working hours, with containers dropped off during the night transported to the Nevada Test Site the following morning. A staff of three would be adequate to conduct operations at the station. Trucks would be inspected and decontaminated, as necessary, at the Nevada Test Site before returning to the station (DIRS 103225-DOE 1998, pp. 2-1 to 2-10 unless otherwise noted).

A high-end estimate for the planned trucking operation to support the low-level radioactive waste intermodal transfer station indicates a terminal on about 0.04 to 0.06 square kilometer (10 to 15 acres), a maintenance building 21 by 23 meters (70 by 75 feet), 9 tractors and 27 trailers, and 11 employees. One proposed location would be south and just outside of Caliente. Trucks would not pass through the Town of Caliente to reach the intermodal transfer station site (DIRS 103225-DOE 1998, p. 5-4).

The projections of low-level radioactive waste shipments from current DOE-approved generators to the Nevada Test Site do not extend to 2010 when shipments of spent nuclear fuel and high-level radioactive waste would begin to the proposed Yucca Mountain Repository. However, because it is reasonable to assume that low-level radioactive waste shipments to the Nevada Test Site could continue and occur coincidentally with shipments to the Yucca Mountain Repository, Section 8.4 analyzes the potential for cumulative impacts from the construction and operation of these two intermodal transfer stations as well as a privately owned intermodal transfer station described in the following section.

Timbisha Shoshone Reservation

The Secretary of the Interior issued a draft report to Congress (DIRS 103470-Timbisha Shoshone and DOI 1999, all) describing a plan to establish a discontiguous reservation for people of the Timbisha Shoshone Tribe in portions of the Mojave Desert in eastern California and southwestern Nevada. On

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November 1, 2000, the President signed Bill S.2102 (Public Law 106-423) to provide a permanent land base for the Timbisha Shoshone Tribe within its ancestral homeland.

The National Park Service of the U.S. Department of the Interior prepared a Legislative EIS (DIRS 154121-DOI 2000, all), which describes the environmental impacts of this action. The EIS analyzes the potential transfer of almost 32 square kilometers (7,800 acres) in five noncontiguous parcels in portions of the Mojave Desert in eastern California and southwestern Nevada, as follows:

- Approximately 1.3 square kilometers (314 acres) in Furnace Creek, Death Valley National Park, California
- Approximately 4 square kilometers (1,000 acres) in Death Valley Junction, California
- Approximately 11 square kilometers (2,800 acres) in Scottys Junction, Nevada
- Approximately 2.6 square kilometers (640 acres) in Centennial, California
- Approximately 12 square kilometers (3,000 acres) in Lida, Nevada

Of these five parcels, the first three are in whole or in part within the 80-kilometer (50-mile) radius of the proposed repository. In addition to these five parcels, the Law authorizes the Secretary of the Interior to purchase two additional parcels of land with water rights as follows:

- Approximately 0.49 square kilometer (120 acres) at the Indian Rancheria Site, California
- Approximately 9.5 square kilometers (2,340 acres) at Lida Ranch, Nevada

In addition, Public Law 106-423 prescribes Federal water rights for these parcels of land and describes partnerships between the National Park Service and the Timbisha Shoshone Tribe that will provide economic and cultural opportunities for the Tribe while preserving the resources in the area. As described in the Legislative EIS (DIRS 154121-DOI 2000, all), activities on the parcels of land would not differ greatly from their historic uses. Modern housing with the associated infrastructure could be constructed at the Furnace Creek site, but would be limited by law to conserve and protect resources. Commercial development is permitted at several of the sites, but would have to be consistent with existing designations and uses of the land. The future development could cause potential transportation impacts, but the lack of information on specific plans precludes a detailed analysis at this time.

Because of the proximity of some of the parcels to the proposed repository and to some of the transportation corridors, there are potential cumulative impacts between their use and the proposed repository with regard to land use, regional water use, and transportation impacts. Therefore, DOE considered this action in its analysis of cumulative impacts in this chapter. As discussed in Chapter 6, the parcel near Scottys Junction (shown in Figure 8-1), if inhabited, could be affected if a rail corridor was used in the future.

8.1.2.3 Non-Federal and Private Actions

The following paragraphs describe reasonably foreseeable future actions of non-Federal and private agencies or individuals that could result in cumulative impacts. This EIS considers the Cortez Pipeline Gold Deposit projects described below to be private actions even though they require the approval of the Bureau of Land Management.

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Cortez Pipeline Gold Deposit Projects

The Cortez Gold Mine Pipeline Project is near the potential branch rail line in the Carlin Corridor in Nevada (see Chapter 6, Section 6.3.2.2.2). Cortez Gold Mine, Inc., operates the Pipeline Project mine and processing facility; the environmental impacts of the existing mining operation are discussed in the *Cortez Pipeline Gold Deposit: Final Environmental Impact Statement* (DIRS 103078-BLM 1996, all). The Pipeline Infiltration Project (which was approved in March 1999) would expand the Pipeline Project area to add more land for the construction and operation of infiltration ponds to support the existing mine (DIRS 103081-BLM 1999, all). The Bureau of Land Management published the *South Pipeline Project Final Environmental Impact Statement* (DIRS 155530-BLM 2000, all) in which the proposed action was to “develop the South Pipeline ore deposit and construct associated facilities to continue to extract gold from the mined ore within the existing Project Area.” Based on an analysis of the general area potentially affected by the Cortez Gold Mine Project, there could be cumulative land-use and ownership impacts with the proposed Carlin rail corridor (see Figure 8-2). The Bureau issued the Record of Decision for the EIS on June 27, 2000 (DIRS 155095-BLM 2000, all). On July 31, 2000, the Western Mining Action Project (representing Great Basin Mine Watch, Western Shoshone Defense Project, and Mineral Policy Center) filed an Appeal and Request for Stay (DIRS 155531-BLM 2001, all); however, the stay request was denied in January 2001.

Apex Bulk Commodities Intermodal Transfer Station

Apex Bulk Commodities is negotiating with BHP Copper of Ely, Nevada, to build an intermodal transfer station at Caliente near the potential intermodal transfer station site for shipping spent nuclear fuel and high-level radioactive waste to the proposed Yucca Mountain Repository. Apex anticipates one diesel truck per hour carrying 40 tons of copper concentrate, 24 hours per day, for 15 years. An improved access road and about 4,200 meters (14,000 feet) of new rail would be constructed. The transfer facility would be housed in a building 90 by 30 meters (300 by 100 feet) designed to retain dust, water, and spills generated during the transfer process. Air emission particulates would be collected in two baghouses. Apex would also need a truck maintenance facility, which would be in a building 30 by 18 meters (100 by 60 feet). An above-ground storage tank for about 45,000 liters (12,000 gallons) of diesel fuel is also planned. Apex estimates 25 new jobs for Caliente and an annual payroll of $800,000 (DIRS 103225-DOE 1998, p. 5-5).

Although a start date for Apex copper concentration intermodal transfer station and truck transportation operations is unknown, Section 8.4 analyzes the potential for cumulative impacts from the construction and operation of that station, assuming these activities would coincide with impacts from the Nevada Test Site low-level radioactive waste intermodal transfer station and the intermodal transfer station for shipments to the proposed Yucca Mountain Repository.

Shared Use of a DOE Branch Rail Line

If DOE built a branch rail line to transport spent nuclear fuel and high-level radioactive waste to the Yucca Mountain Repository, it could share the use of this line with others. A branch rail line in the Carlin corridor could provide transportation service options for mine operators in the central mountain valleys of Nevada and could provide freight service options for southwestern Nevada communities such as Tonopah, Beatty, Goldfield, and Pahrump. A branch rail line in the Caliente corridor could serve those communities plus Warm Springs, along with mine operators in the interior of Nevada. A branch rail line in the Valley Modified or Jean corridors would provide freight service access to farms, industries, and businesses in the Amargosa Valley and Pahrump communities. A Valley Modified branch line would also provide rail service to the Indian Springs community. Any of the potential branch rail lines to the Yucca Mountain site (see Chapter 6, Figure 6-14) would provide rail access to the Nevada Test Site. The shared use of a branch rail line would have positive economic benefits, but could produce cumulative impacts due to increased operations and traffic.

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Private Fuel Storage at Skull Valley

In June 2000, the Nuclear Regulatory Commission published the *Draft Environmental Impact Statement for the Construction and Operation of an Independent Spent Fuel Storage Installation on the Reservation of the Skull Valley Band of Goshute Indians and the Related Transportation Facility in Tooele County, Utah* (DIRS 152001-NRC 2000, all). That EIS evaluates the environmental impacts of constructing and operating a facility for the interim storage of commercial spent nuclear fuel.

The storage site would be on the reservation of the Skull Valley Band of Goshute Indians in Skull Valley in Tooele County, Utah. The facility would occupy approximately 3.3 square kilometers (820 acres) and would involve construction of a 52-kilometer (32-mile) rail line on public land administered by the Bureau of Land Management from Skunk Ridge (near Low, Utah) to the reservation.

The facility would be constructed and operated by Private Fuel Storage, LLC, a limited liability company comprised of eight U.S. power utilities.

The storage site would be designed to store up to 40,000 metric tons of heavy metal (MTHM) of commercial spent nuclear fuel, which is sufficient to store all the spent nuclear fuel from the Private Fuel Storage member utilities as well as additional fuel from non-member utilities. The fuel would be stored in above-ground concrete vault structures that would provide structural integrity and radiation shielding. The proposed facility would be licensed by the Nuclear Regulatory Commission to operate for as long as 20 years, at which time the Commission could renew the license.

The facility would be used as an interim storage facility until a geologic repository was available for disposal of the spent nuclear fuel. Therefore, the actions considered in the Nuclear Regulatory Commission EIS could have cumulative impacts with those contemplated in the Yucca Mountain EIS by affecting the transportation routes through which material would arrive at the proposed repository. However, because of the distance of the storage facility from the Yucca Mountain site, DOE does not expect cumulative impacts between the proposed operation of the facility and the Proposed Action for this EIS.

Section 8.4 discusses estimated impacts from transportation of material to the Private Fuel Storage facility.

Owl Creek Energy Project

The Owl Creek Energy Project (DIRS 155595-Stuart and Anderson 1999, all) is a potential interim storage project for commercial spent nuclear fuel that would be developed in the State of Wyoming. The location for the project is near the Town of Shoshoni, Wyoming, and consists of about 11 square kilometers (2,700 acres) of privately owned land with access to rail and nearby roads. A private company is pursuing the project, which would be temporary, with a projected life of 40 years.

The Owl Creek Energy Project would involve the storage of spent nuclear fuel using dry storage techniques in specially designed facilities. However, the project is still in its infancy; no license application has been submitted to the Nuclear Regulatory Commission. Further, the potential impacts of the facility are unknown at present. Therefore, DOE has not attempted to quantify potential impacts at this time, but believes it would be unlikely that the operational impacts would be markedly different from those expected for the Private Fuel Storage Facility in Tooele County, Utah (described above).

Moapa Paiute Energy Center

In March 2001, the Bureau of Indian Affairs issued the *Moapa Paiute Energy Center Draft Environmental Impact Statement* (DIRS 155979-PBS&J 2001, all). Calpine Corporation proposes to construct the Moapa Paiute Energy Center on 0.26 square kilometer (65 acres) of land leased from the Moapa River Paiute Reservation approximately 12 kilometers (45 miles) northeast of Las Vegas. The plant would consist of a nominal 760-megawatt baseload natural-gas-fired, combined-cycle power unit with peak capacity to approximately 1,100 megawatts. The land disturbance would consist of as much as 0.88 square kilometer (218 acres) of reservation land and as much as 0.33 square kilometer (82 acres) of off-reservation lands. Transmission lines would follow an existing Bureau of Land Management utility corridor that passes through the reservation, requiring no change in land use. The lines would pass approximately 19 kilometers (12 miles) to the southwest to the existing Nevada Power Company Harry Allen Substation. The natural gas supply system to the facility would consist of approximately 1,220 meters (4,000 feet) of pipeline and a pumping station. The natural gas line and the pump station would require approximately 0.004 square kilometer (5.5 acres). The Bureau of Land Management would be responsible for rights-of-way for construction, operation, and termination for the facilities in the utility right-of-way on the reservation.

Because the Energy Center would be some distance from the proposed repository, there is minimal potential for direct cumulative impacts with repository operation. Groundwater management practices would minimize depletion of groundwater resources. Air emissions would be minimized, and there would be essentially no potential for overlap of the plumes from the repository and the Energy Center.

Southern Nevada Public Land Management Act

The Southern Nevada Public Land Management Act (Public Law 105-263) authorizes the Bureau of Land Management to sell some public lands in the Las Vegas Valley to promote responsible and orderly development.

The law specifies that money generated by these land sales will remain in Nevada. This money will provide funding for a variety of land management activities emphasizing recreation sites, such as the following:

- Acquisition of environmentally sensitive land in Nevada, with priority given to lands in Clark County
- Capital improvements at the Lake Mead National Recreation Area, the Desert National Wildlife Refuge, the Red Rock Canyon National Conservation Area, and other areas administered by the Bureau of Land Management in Clark County, and the Spring Mountains National Recreation Area (subject to an annual limitation)
- Development of a multispecies habitat conservation plan in Clark County, Nevada
- Development of parks, trails, and natural areas in Clark County

The Act included approximately 110 square kilometers (27,000 acres) of land for sale (Public Law 105-263). As of April 2001, the Bureau of Land Management had conveyed about 17 square kilometers (4,200 acres) to private and commercial entities. In December 2000, the Bureau published its “Round 2 Preliminary Recommendation” in which it recommended the acquisition of more than 23 square kilometers (5,800 acres) of land throughout Nevada that is privately or commercially owned to be distributed among the Bureau, the National Park Service, and the Forest Service (DIRS 155597-BLM 2000, all).

This action has potential land use cumulative impacts because some of the parcels conveyed or acquired by the Bureau of Land Management could be either within the 80-kilometer (50-mile) radius of the proposed repository or near potential transportation corridors, although DOE cannot predict which parcels might be affected or the timing of such conveyances.

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Ivanpah Valley Airport

On October 27, 2000, the President signed the Ivanpah Valley Airport Public Lands Transfer Act (Public Law 106-362) to transfer Federal lands in Ivanpah Valley, Nevada, to Clark County. The land to be transferred, which is part of the Mojave National Preserve, would be used for construction of a general aviation airport at Jean, Nevada.

The passage of the Ivanpah Valley Airport Public Lands Transfer Act does not automatically transfer the lands. Under provisions of the bill, the U.S. Departments of the Interior and Transportation must complete an environmental impact statement before an actual transfer. As described in Chapter 6, the initiation of the Stateline option of the Jean Corridor for a potential branch rail line encroaches upon the land to be transferred. Therefore, this EIS evaluates the potential for cumulative impacts due to the land transfer.

Desert Space Station Science Museum

The Nevada Science and Technology Center is proposing to construct an 8,800-square-meter (95,000-square-foot) museum on 1.8 square kilometers (450 acres) of land in Amargosa Valley at the intersection of U.S. Highway 95 and State Route 373 (DIRS 148148-Williams and Levy 1999, p. 1). The land would be transferred from the Bureau of Land Management to Nye County, which in turn would lease the land to the Nevada Science and Technology Center (DIRS 155478-Dorsey 2001, all). As shown in Figure 8-2, this parcel of land is near the Nevada Test Site and is, thus, within the region of influence for the proposed repository.

Because detailed quantitative impact information is not available, DOE has not included a detailed analysis of this action other than to report the potential land use implications in Section 8.2.1.

8.2 Cumulative Short-Term Impacts in the Proposed Yucca Mountain Repository Region

This section describes short-term cumulative impacts during the construction, operation and monitoring, and closure of the repository in the regions of influence for the resources the repository could affect. DOE has organized the analysis of cumulative impacts by resource area. As necessary, the discussion of each resource area includes cumulative impacts from Inventory Module 1 or 2; from other Federal, non-Federal, and private actions; and from the combination of Inventory Modules 1 and 2 and other Federal, non-Federal, and private actions. Table 8-5 summarizes these impacts. The impacts listed for the Proposed Action in Table 8-5 include the combined effects of the potential repository and transportation activities.

There would be essentially no difference in the design and operation of the repository for Inventory Modules 1 and 2. As described in Appendix A, the radioactive inventory for Greater-Than-Class-C waste and for Special-Performance-Assessment-Required waste is much less than that for spent nuclear fuel and high-level radioactive waste. The subsurface emplacement of the material in Inventory Module 2, in comparison with the inventory for Module 1, would not greatly increase radiological impacts to workers or the public (DIRS 104523-CRWMS M&O 1999, p. 6-44). For the surface facilities, the number of workers and the radiological exposure levels would be the same for Inventory Modules 1 and 2 (DIRS 104508-CRWMS M&O 1999, Tables 6-1, 6-2, 6-4, and 6-5). Therefore, DOE did not perform separate analyses for Modules 1 and 2 to estimate the short-term impacts. This section identifies the short-term impacts as being for Modules 1 and 2, indicating that the impacts for the two modules would not differ greatly.

Table 8-5. Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region (page 1 of 8).

Resource area	Proposed Action (repository and transportation)	Inventory Module 1 or 2[a]	Other Federal, non-Federal, and private actions	Total cumulative impacts
Land use and ownership	Withdraw about 600 square kilometers (150,000 acres) of land already under Federal control by DOE, U.S. Air Force, and Bureau of Land Management. Public access to about 200 square kilometers (50,000 acres) of BLM public lands would be terminated. About 6.0 square kilometers (1,500 acres) of withdrawn land would be disturbed for the repository under the Proposed Action. As much as 20 square kilometers (4,900 acres) of land would be disturbed along transportation routes in Nevada, a portion of which would be in the Yucca Mountain region and could include the need for rights-of-way agreements or withdrawals.	Land withdrawal impacts would be the same as those for the Proposed Action. As much as 1 square kilometer (250 acres) of additional land would be disturbed, for a total of as much as 7.0 square kilometers (1,730 acres). Land use and ownership impacts from transportation would be the same as for the Proposed Action.	In addition to impacts for the Proposed Action, under current and reasonably foreseeable actions, 10,000 acres of federal land would be transferred for Indian reservations; 65 acres of reservation land would be used for commercial purposes; in excess of 38,000 acres of Federal land would be used for private and commercial purposes. There is the potential for over 5,800 acres of privately owned land to be acquired by the Federal Government. An intermodal transfer station could be constructed for shipping low-level radioactive waste within the Yucca Mountain region.	Withdraw about 600 square kilometers (150,000 acres) of land already under Federal control by DOE, U.S. Air Force, and Bureau of Land Management. Public access to about 200 square kilometers (50,000 acres) of BLM public lands would be terminated. As much as 27 square kilometers (1,100 acres) of withdrawn land would be disturbed for the repository and along transportation route. In addition to impacts for the Proposed Action, under current and reasonably foreseeable actions, 10,000 acres of federal land would be transferred for Indian reservations; 65 acres of reservation land would be used for commercial purposes; in excess of 38,000 acres of Federal land would be used for private and commercial purposes. There is the potential for over 5,800 acres of privately owned land to be acquired by the Federal Government.
Air Quality				
Nonradiological	Criteria pollutant [nitrogen dioxide, sulfur dioxide, carbon monoxide, and particulate matter (PM_{10}, $PM_{2.5}$)] and cristobalite concentrations calculated at the analyzed land withdrawal area boundary would be less than 6 percent of applicable regulatory limits (see Tables 8-6, 8-7, and 8-8). Emissions associated with transportation in the proposed repository region would be low.	Criteria pollutant and cristobalite concentrations calculated at the analyzed land withdrawal area boundary would be less than 7 percent of applicable regulatory limits (see Tables 8-6, 8-7, and 8-8). Emissions associated with transportation in the proposed repository region would be low.	Nevada Test Site: Baseline monitoring shows that criteria pollutants at the Nevada Test Site and in the proposed repository region are well below National Ambient Air Quality Standards and would result in very small cumulative nonradiological air quality impacts. Emissions associated with the transportation of waste, people, and materials for Nevada Test Site activities in the repository region would be low.	Criteria pollutant and cristobalite concentrations calculated at the analyzed land withdrawal area boundary would be small fractions of applicable regulatory limits (generally less than 10 percent). Emissions associated with transportation in the repository region would be low.

Table 8-5. Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region (page 2 of 8).

Resource area	Proposed Action (repository and transportation)	Inventory Module 1 or 2[a]	Other Federal, non-Federal, and private actions	Total cumulative impacts
Air Quality (continued)				
Radiological[b]	The maximally exposed individual in the public would receive an estimated annual radiation dose of 1.3 millirem or less (see Tables 8-10, 8-11, 8-12, and 8-13), primarily from naturally occurring radon.	The maximally exposed individual in the public would receive an estimated annual dose of 2.2 millirem or less, primarily from naturally occurring radon.	Nevada Test Site: Activity would continue to contribute extremely small increments to the risk to the general population and should not increase injury or mortality rates. As an example, the maximally exposed individual in the public would receive an estimated annual radiation dose of less than 0.15 millirem from past, present and reasonably foreseeable future activities.	The maximally exposed individual in the public would receive an annual radiation dose of 2.5 millirem or less, which is well below the 10 CFR 63.204 limit of 15 millirem from radioactive material releases from the repository and the Nevada Test Site.
Hydrology				
Surface water	Between 2.8 and 4.5 square kilometers (690 and 1,100 acres) of land would be newly disturbed and resulting impacts would likely be small and limited to the site. Impacts from construction and use of transportation capabilities (heavy-haul and rail) in the site vicinity and region would result in small impacts to surface water. Minor changes to runoff and infiltration rates. Floodplain/wetlands assessment concluded impacts would be small. Additional transportation floodplain/wetlands assessments would be performed in the future as necessary.	Would be similar to impacts from the Proposed Action with an increase of as much as 1 square kilometer (250 acres) in new surface disturbance for a total of as much as 5.5 square kilometers (1,360 acres). Impacts from construction and use of transportation capabilities (heavy-haul and rail) would be small. Minor changes to runoff and infiltration rates. Floodplain/wetlands assessment concluded impacts would be small. Transportation floodplain/wetlands assessments would be performed in the future as necessary.	No other actions were identified with potential cumulative surface-water impacts within the region of influence of repository construction, operation and monitoring, and closure. Transportation impacts would be small.	As much as 5.5 square kilometers (1,360 acres) of land would be newly disturbed and resulting impacts would likely be minor and limited to the site. Impacts from construction and use of transportation capabilities (heavy-haul and rail) in the site vicinity and region would result in small impacts to surface water. Minor changes to runoff and infiltration rates. Floodplain/wetlands assessment concluded impacts would be small. Transportation floodplain/wetlands assessments would be performed in the future as necessary.

Table 8-5. Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region (page 3 of 8).

Resource area	Proposed Action (repository and transportation)	Inventory Module 1 or 2[a]	Other Federal, non-Federal, and private actions	Total cumulative impacts
Hydrology (continued)				
Groundwater	Annual water demand would be between 230 and 290 acre-feet (during emplacement), and below the lowest estimate of perennial yield of the western two-thirds of the Jackass Flats basin (580 acre-feet). Water use for the construction of a rail line could be as much as 710 acre-feet from multiple wells and hydrographic areas over 4 years.	Anticipated annual water demand (below Nevada State Engineer's ruling on perennial yield) could be slightly higher (ranging from 240 to 320 acre-feet) than that of the Proposed Action, and the highest demand, which would also occur when emplacement and development activities occurred together, would extend for an additional 14 years. Water use for transportation would be the same as that for the Proposed Action.	Nevada Test Site: Anticipated annual water demand from Nevada Test Site activities would be about 280 acre-feet, which is less than the estimate of perennial yield of the western two-thirds of the Jackass Flats basin (580 acre-feet).	Combining the highest annual water demand of the repository of 320 acre-feet (during emplacement and development activities for the lower-temperature maximum spacing scenario with Modules 1 or 2) with annual water withdrawals from the Nevada Test Site of 280 acre-feet would result in a total of 600 acre-feet, which would slightly exceed the lowest estimate of perennial yield of the western two-thirds of the Jackass Flats basin (580 acre-feet), but would not approach the highest estimate of perennial yield, which is 4,000 acre-feet. There is a potential for drawdown of the water level in nearby wells from water withdrawal. The combined peak annual water use of a repository under other operation options, even with Modules 1 or 2, with Nevada Test Site annual water use would result in a maximum peak cumulative use of about 560 acre-feet per year, which is below the lowest estimate of perennial yield of the western two-thirds of the Jackass Flats basin (580 acre-feet). In addition, up to 710 acre-feet of water over 2.5 years would be used to construct a rail line in Nevada.

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Table 8-5. Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region (page 4 of 8).

Resource area	Proposed Action (repository and transportation)	Inventory Module 1 or 2[a]	Other Federal, non-Federal, and private actions	Total cumulative impacts
Biological resources and soils	Between 2.8 and 4.5 square kilometers (690 to 1,100 acres) of soil, habitat, and vegetation would be newly disturbed, resulting in lost productivity and animal mortality and displacement. Adverse impacts to the desert tortoise and loss of individuals would occur. Wetland assessment concluded impacts would be small. Impacts from transportation would include the loss of 0 (legal-weight truck) to 20 square kilometers (4,900 acres) (rail) of habitat in Nevada. Impacts to the desert tortoise probably would occur if a rail line were constructed. Additional wetlands assessments would be performed in the future as necessary.	Inclusive of the Proposed Action, a total of as much as 5.5 square kilometers (1,360 acres) of soil, habitat, and vegetation would be disturbed, resulting in lost productivity and animal mortality and displacement. Adverse impacts to the desert tortoise would occur. Wetland assessment concluded impacts would be small. Impacts from transportation would be the same as those under the Proposed Action. Additional wetlands assessments would be performed in the future as necessary.	No other actions were identified with potential cumulative biological resource or soil impacts within the region of influence of repository construction, operation and monitoring, and closure.	As much as 5.5 square kilometers (1,360 acres) of soil, habitat, and vegetation would be newly disturbed, resulting in lost productivity and animal mortality and displacement. Adverse impacts to the desert tortoise and loss of individuals would occur. Impacts to potential jurisdictional wetlands would be very small and minimized. Impacts from transportation would include the loss of 0 (legal-weight truck) to 20 square kilometers (4,900 acres) (rail) of habitat in Nevada, a portion of which would be within the Yucca Mountain vicinity. Impacts to the desert tortoise and wetlands probably would occur if a rail line were constructed. Additional wetlands assessments would be performed in the future as necessary.

Table 8-5. Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region (page 5 of 8).

Resource area	Proposed Action (repository and transportation)	Inventory Module 1 or 2[a]	Other Federal, non-Federal, and private actions	Total cumulative impacts
Cultural resources	Repository development would disturb about 2.8 to 4.5 square kilometers (690 to 1,100 acres). Direct and indirect impacts (damage to archaeological and historical sites or illicit collection of artifacts) would be mitigated per applicable regulations. In addition, as much as 20 square kilometers (4,900 acres) would be disturbed along transportation routes in Nevada. Native Americans view all impacts to be adverse and immune to mitigation.	Land disturbance for repository development would increase to a total of as much as 5.5 square kilometers (1,360 acres). Transportation impacts would be the same as those under the Proposed Action. Direct and indirect impacts and mitigations would be similar to the Proposed Action. Native Americans view all impacts to be adverse and immune to mitigation.	No other actions were identified with potential cumulative cultural resource impacts within the region of influence of repository construction, operation and monitoring, and closure. Native Americans view all impacts to be adverse and immune to mitigation.	Repository development would disturb as much as 5.5 square kilometers (1,360 acres). As much as 20 square kilometers (4,900 acres) would be disturbed if a rail line was constructed in Nevada. Direct and indirect impacts (damage to archaeological and historical sites or illicit collection of artifacts) would be mitigated per applicable regulations. Native Americans view all impacts to be adverse and immune to mitigation.
Socioeconomics	Estimated peak direct employment of 3,400 occurring in 2006 would result in less than a 1 percent increase in direct and indirect regional employment. Employment increases would range from less than 1 percent to approximately 5 percent (use of intermodal transfer station or rail line in Lincoln County, Nevada) of total employment by county.	Estimated peak direct employment would be the same as for the Proposed Action.	Nevada Test Site: Any employment increases would occur prior to construction of the repository and no cumulative impacts would be expected.	Estimated peak employment increase of about 3,400 occurring in 2006 would result in less than a 1-percent increase in direct and indirect regional employment (with as much as a 5-percent change in Lincoln County, Nevada if intermodal transfer station or rail line were located there).
Occupational and public health and safety[d]				
Nonradiological health impacts	2 to 3 fatalities[e] during construction, operation and monitoring, and closure. Exposures well below regulatory limits. Also, between 14 and 26 fatalities[e] from commuting, and transportation of material (repository and rail line construction material, as well as spent nuclear fuel and high-level radioactive waste).	4 or less fatalities[e] during construction, operation and monitoring, and closure. Exposures well below regulatory limits. Also, between 19 and 33 fatalities[e] from commuting, and transportation of material (repository and rail line construction material, as well as spent nuclear fuel and high-level radioactive waste).	No other actions were identified with potential cumulative industrial hazard impacts to repository workers.	23 to 37 fatalities[e] during construction, operation and monitoring, and closure (including transportation). Exposures well below regulatory limits.

Table 8-5. Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region (page 6 of 8).

Resource area	Proposed Action (repository and transportation)	Inventory Module 1 or 2[a]	Other Federal, non-Federal, and private actions	Total cumulative impacts
Occupational and public health and safety (continued)[d]				
Radiological health impacts				
Workers	4 to 7 latent cancer fatalities[e] from repository construction, operation and monitoring, and closure. Up to 3 to 12 latent cancer fatalities[e] to workers from mostly rail and mostly truck, respectively.	5 to 8 latent cancer fatalities[e] from repository construction, operation and monitoring, and closure. Up to 7 to 24 latent cancer fatalities[e] to workers from mostly rail and mostly truck, respectively.	No other actions were identified with potential cumulative radiological health impacts to repository workers.	About 12 to 32 latent cancer fatalities[e] from repository construction, operation and monitoring, and closure (including transportation).
Public	Estimated doses would result in less than 1 latent cancer fatality to the public from repository construction, operation and monitoring, and closure. Up to 1 to 3 latent cancer fatalities[e] would result from transport by mostly rail and mostly truck, respectively.	Estimated doses would result in less than one latent cancer fatality to the public from repository construction, operation and monitoring, and closure. Impacts from transportation would be almost twice those from the Proposed Action.	Nevada Test Site: Estimated doses and associated health effects from the Nevada Test Site would be less than one latent cancer fatality.	About 2 to 5 latent cancer fatalities[e] from repository construction, operation and monitoring, and closure (including transportation); and Nevada Test Site activities.
Accidents	No latent cancer fatalities would be likely from the maximum reasonably foreseeable repository accident scenarios. Between 1 and 5 latent cancer fatalities would result from a maximum reasonably foreseeable transportation accident scenario that has less than 3 chances in 10 million of occurring.	The accident risk (probability of occurrence times consequence) is essentially the same as that for the Proposed Action. Impacts of a maximum reasonably foreseeable transportation accident scenario would be the same as those for the Proposed Action.	No other actions were identified with potential cumulative accident risk impacts.	No latent cancer fatalities would be likely from the maximum reasonably foreseeable repository accident scenarios. Between 1 and 5 latent cancer fatalities would result from a maximum reasonably foreseeable transportation accident scenario that has less than 3 chances in 10 million of occurring.

Table 8-5. Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region (page 7 of 8).

Resource area	Proposed Action (repository and transportation)	Inventory Module 1 or 2[a]	Other Federal, non-Federal, and private actions	Total cumulative impacts
Noise	Impacts from construction, operation and monitoring, and closure of a repository would result in low noise impacts. Noise levels would be transient, less than 90 dBA[c]. New intermittent noise source if a rail line was used in Nevada, including in the Yucca Mountain region.	Same as the Proposed Action.	Future development of the Timbisha Shoshone Homeland parcel near Scottys Junction could result in residents or businesses being exposed to up to 90 dB of noise from the transportation route.	Impacts from construction, operation and monitoring, and closure of a repository would result in low noise impacts. Noise levels would be transient, less than 90 dBA[c]. New intermittent noise source if a rail line was used in Nevada, including in the Yucca Mountain.
Aesthetics	Placement of exhaust stacks on top of Yucca Mountain could possibly impact visual resources, since stacks would be visible for some distance. If the stacks were equipped with beacons, the visual effect would be more noticeable at night. Rail line construction would occur if rail was used in Nevada. Possible conflict with visual resource management goals for Jean rail corridor.	Same as the Proposed Action.	Disturbed areas are likely on former federal lands that are used for commercial and private purposes. Acquisition of private lands by the federal government could result in reduced aesthetics impacts and possible return of land to natural state.	Placement of exhaust stacks on top of Yucca Mountain could possibly impact visual resources, since stacks would be visible for some distance. If the stacks were equipped with beacons, the visual effect would be more noticeable at night. Rail line construction would occur if rail was used in Nevada. Possible conflict with visual resource management goals for Jean rail corridor. Disturbed areas are likely on former federal lands that are used for commercial and private purposes. Acquisition of private lands by the federal government could result in reduced aesthetics impacts and possible return of land to natural state.
Utilities, energy, materials, and site services	Peak electric power demand would require an upgrade to the electrical transmission and distribution system. Adverse impacts on energy and material supplies or to site services would be unlikely, including materials needed for transportation capabilities in the Yucca Mountain vicinity.	Peak electric power demand would require upgrade to the electrical transmission and distribution system. Although requirements for electricity, fossil fuels, concrete, steel, and copper would increase, adverse impacts to energy and material supplies or to site services would be unlikely, including materials needed for transportation capabilities in the Yucca Mountain vicinity.	Construction of other energy supply facilities, such as the Moapa Paiute Energy Center or the Alternative Energy Facility at the Nevada Test Site could provide additional electrical capacity for the region.	Peak electric power demand would require upgrade to the electrical transmission and distribution system. (See Chapter 4, Section 4.1.11.) Adverse impacts on energy and material supplies or to site services would be unlikely, including materials needed for transportation capabilities in the Yucca Mountain vicinity.

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Table 8-5. Summary of cumulative short-term impacts in the proposed Yucca Mountain Repository region (page 8 of 8).

Resource area	Proposed Action (repository and transportation)	Inventory Module 1 or 2[a]	Other Federal, non-Federal, and private actions	Total cumulative impacts
Waste management	Disposal of repository-generated low-level waste would require about 4 percent of the reserve capacity of the Nevada Test Site. If nonradioactive, nonhazardous solid waste would be disposed of at the Nevada Test Site, existing landfills would need to be expanded.	Disposal of repository-generated low-level waste would require about 9 percent of the reserve capacity of the Nevada Test Site. If nonradioactive, nonhazardous solid waste would be disposed of at the Nevada Test Site, the larger quantity of this waste would require even further landfill expansion at the Nevada Test Site.	Nevada Test Site: The total low-level radioactive waste disposal capacity of the Nevada Test Site is sufficient and would not be exceeded by the combined actions of repository development and selection of the Nevada Test Site as a regional disposal site for DOE-complex-wide low-level radioactive and mixed wastes.	The Nevada Test Site has sufficient capacity for low-level radioactive waste from all reasonably foreseeable future actions. If nonradioactive, nonhazardous solid waste would be disposed of at the Nevada Test Site, existing landfills would need to be expanded.
Environmental justice	No disproportionately high and adverse impacts to minority or low-income populations would occur for repository or transportation activities. DOE recognizes that Native American people living in the region near Yucca Mountain have concerns about the protection of traditions and the spiritual integrity of the land that extend to the propriety of the Proposed Action, and that implementing the Proposed Action would continue restrictions on access to the proposed site.	No disproportionately high and adverse impacts to minority or low-income populations would occur for repository or transportation activities. DOE recognizes that Native American people living in the region near Yucca Mountain have concerns about the protection of traditions and the spiritual integrity of the land that extend to the propriety of the Proposed Action, and that implementing the Proposed Action would continue restrictions on access to the proposed site.	No other actions were identified with potential cumulative impacts within the region of influence of repository construction, operation and monitoring, and closure that would create environmental justice concerns. DOE recognizes that Native American people living in the region near Yucca Mountain have concerns about the protection of traditions and the spiritual integrity of the land that extend to the propriety of the Proposed Action, and that implementing the Proposed Action would continue restrictions on access to the proposed site.	No disproportionately high and adverse cumulative impacts to minority or low-income populations would occur for repository or transportation activities. DOE recognizes that Native American people living in the region near Yucca Mountain have concerns about the protection of traditions and the spiritual integrity of the land that extend to the propriety of the Proposed Action, and that implementing the Proposed Action would continue restrictions on access to the proposed site.

a. As described in Section 8.1.2.1, there would be essentially no difference in the design and operation of the repository for Inventory Module 1 or 2. Therefore, the analysis considered cumulative impacts from Inventory Module 2 to be the same as those from Inventory Module 1.

b. DOE compared the estimated annual dose to the Preclosure Public Health and Environmental Standard found at 10 CFR 63.204, which is 15 millirem per year to a member of the public.

c. dBA = A-weighted decibels, a common sound measurement. A-weighting accounts for the fact that the human ear responds more effectively to some pitches than to others. Higher pitches receive less weighting than lower ones.

d. Occupational and public health and safety impacts for the Proposed Action and Inventory Module 1 or 2 include both impacts from transportation activities in the repository region of influence as well as impacts estimated to occur nationally from transportation of spent nuclear fuel and high-level radioactive waste.

e. These ranges represent the maximum for each environmental resource area. Because the maximum could occur for different implementing alternatives in the various resource areas, simple addition of these summary level maximums could overstate the impacts due to mixing of incompatible alternatives.

DOE performed quantitative calculations for long-term impacts for both modules (see Section 8.3.1). The conclusion from these quantitative estimates was that the long-term impacts for Modules 1 and 2 would not differ greatly.

In estimating the potential impacts considered in this EIS, DOE consulted various documents, including resource plans, other National Environmental Policy Act documents, and technical documents. If appropriate, DOE has cited these documents in the discussion of each technical discipline.

Based on comments received during scoping and on the Draft EIS, DOE considered the Special Nevada Report from September 1991 (DIRS 153277-SAIC 1991, all) for inclusion as a source of technical information for the EIS. The Special Nevada Report, which was mandated by the Military Lands Withdrawal Act of 1986, contains a description of defense-related activities (as identified in 1991) along with estimates of potential impacts from those activities. However, the cumulative impacts analysis in this chapter considered the agencies that report represents—the Department of the Air Force, Department of the Navy, and Department of the Interior. Evaluations of the cumulative impacts of repository activities and other agency activities included review of a number of documents that are more current than the Special Nevada Report, including National Environmental Policy Act documents prepared by the Federal agencies listed throughout Section 8.1. Therefore, based on these more recent reports, DOE believes this report does not provide additional insight into projections of future impacts and, therefore, did not use it in its analysis of cumulative impacts.

8.2.1 LAND USE AND OWNERSHIP

The ownership, management, and use of the analyzed land withdrawal area described in Chapter 4, Section 4.1.1 for the Proposed Action would not change for Inventory Module 1 or 2. The amount of land required for surface facilities would increase somewhat for Module 1 or 2 because of the larger storage area for excavated rock and additional ventilation shafts for the larger required repository. This would have no substantial cumulative land-use or ownership impact.

To identify and quantify cumulative impacts for land use, DOE used a twofold approach. Actions that occurred within a 50-mile (80-kilometer) radius of the repository were reviewed for potential contributions to land use impacts. Second, actions that could affect transportation corridors were reviewed for their potential land use impacts. This second group of impacts is discussed in Section 8.4.2.1 (see Table 8-4).

Section 8.1 lists several actions that have the potential for land use impacts. DOE reviewed those actions to identify land areas that could be affected and has quantified, where possible, the amount of land that is subject to new uses. DOE identified how the land use would be converted (for example, undisturbed federal land to commercial use) and any restrictions that might affect the length of time the land would be used.

As discussed in Chapter 3, Section 3.1.1.1, the Federal Government manages approximately 240,000 square kilometers of land in Nevada, approximately 190,000 square kilometers of which are managed by BLM and available for public use. The land transfer/usage indicated in Table 8-6 represents approximately 340 square kilometers of additional land that is currently scheduled for removal from public use. In addition approximately 430 square kilometers would require removal from public use as the result of the potential development of a repository and transportation corridor. The total land removed from public use would represent less than 0.5 percent of BLM land and approximately 0.3 percent of the total Federal lands of Nevada. The largest change in land use is associated with the Southern Nevada Public Land Management Act. Although the Bureau of Land Management could convey as much as 110 square kilometers (27,000 acres) to private and commercial use, only about 17 square kilometers (4,200 acres) had been transferred as of April 30, 2001. As stipulated by the Act,

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Table 8-6. Potential cumulative land use impacts for activities in or near the region of influence.[a]

Action	Land use conversion[b]	Ownership change	Land use restrictions
Moapa Paiute Energy Center[c]	Powerplant construction/ operation on 0.26 square kilometers of Reservation land.	Moapa Band of Paiute Indians to Calpine Corporation – powerplants footprint. Reservation to BLM for management of new natural gas pipeline	25-year lease with 20-year renewal
Ivanpah Cargo Airport[d]	Recreation and mining to airport and industrial development. Approximately 27 square kilometers, 8.1 square kilometers of which is for airport alone.	BLM to Clark County for public/private development	None
Timbisha Shoshone Reservation[e]	Grazing, recreation, mining, wildlife management to Tribal use (economic development, historic/cultural use, special use). Approximately 40 square kilometers.	NPS, BLM, and private lands to reservation/BIA	None
Cortez Mine[f]	Grazing, recreation, mining to mining 18 square kilometers.	BLM lease to Cortez Gold Mine	10 years
NTS Energy Generation Facility (Wind Farm)[g]	DOE land withdrawn for NTS to commercial use–4.9 square kilometers.	NTS subeasement to MNS through NTSDC	20 year generation period
Southern Nevada Public Land Management Act[h,i]	BLM general use to private/ commercial development and private/commercial land to public land. • Potential of 110 square kilometers to be transferred • 17 square kilometers conveyed as of April 30, 2001 • More than 23 square kilometers recommended by BLM to be acquired	• BLM to private/commercial • Private/commercial to BLM, NFS, NPS	None
Desert Space Station Science Museum[j]	BLM general use to commercial use (1.8 square kilometers).	BLM to Nye County	Land leased from Nye County to Nevada Science and Technology Center
Total land use impacts			
Federal land to Indian Reservations:	40 square kilometers		
Federal land to private and commercial use:	154+ square kilometers		
Private to Federal land:	25+ square kilometers (proposed as of December 2000)		

a. BLM = Bureau of Land Management; NTS = Nevada Test Site; NTSDC = NTS Development Corporation; MNS = M&N Wind Power Inc. and Siemans; NPS = National Park Service; BIA = Bureau of Indian Affairs.
b. To convert square kilometers to acres, multiply by 247.1.
c. Source: DIRS 155979-PBS&J (2001, pp. xi and xiii to xviii).
d. Source: Ivanpah Valley Public Lands Transfer Act (Public Law 106-362, 114 Stat. 1404).
e. Source: DIRS 154121-DOI (2000, Section 2.2).
f. Source: DIRS 155095-BLM (2000, pp. 1 to 13).
g. Source: DIRS 154545-DOE (2001, pp. 3-1 to 3-9).
h. Source: *Southern Nevada Public Land Management Act of 1998* (Public Law 105-263, 112 Stat. 2343).
i. Source: DIRS 155597-BLM (2000, all).
j. Source: DIRS 148148-Williams and Levy (1999, p. 1).

the Bureau has recommended acquiring about 23 square kilometers (5,800 acres) of environmentally sensitive lands throughout the State of Nevada that would be transferred from commercial and private use to general Bureau use.

Several land use conversions could result in commercial or private use of Federal lands. In addition to those lands transferred under the Southern Nevada Public Land Management Act, lands would be leased or transferred for the Ivanpah Cargo Airport, the Moapa Paiute Energy Center, the Cortez Mine, and the Desert Space Station Science Museum. These changes in land use would permit orderly development of public lands.

The projects that would occur on the Nevada Test Site and the Nellis Air Force Range would result in no net change in land use because the lands are already removed from the public use and are designated for development.

Some of the lands that would be transferred to the Timbisha Shoshone Nation could have some associated commercial use; however, this use would be consistent with the designations for the areas, and developments would be restricted to maintain the natural resources of the land.

In addition to the cumulative changes to land use and ownership, DOE considered potential conflicts with plans and policies issued by various government entities in the vicinity of the proposed Yucca Mountain Repository. In particular, DOE reviewed a number of documents issued by or in conjunction with Nye County and communities in Nye County. In general, the local governments have expressed goals that would minimize the conversion of private lands to public use. At this time DOE is not aware of any direct operational conflicts between the proposed repository and Nye County planning efforts because the Department does not foresee a need to expand the withdrawal area or for the conversion of private lands in the vicinity of the repository. Transportation-related issues are discussed in Section 8.4.2.1.

8.2.2 AIR QUALITY

8.2.2.1 Inventory Module 1 or 2 Impacts

This section addresses potential nonradiological and radiological cumulative impacts to air quality from emplacement in a repository at Yucca Mountain of the additional quantities of spent nuclear fuel and high-level radioactive waste above those evaluated for the Proposed Action, Greater-Than-Class-C waste, and Special-Performance-Assessment-Required waste (that is, Inventory Modules 1 and 2). It compares potential nonradiological and radiological cumulative impacts to applicable regulatory limits, including the new U.S. Environmental Protection Agency National Ambient Air Quality Standard for particulate matter with a diameter of less than 2.5 micrometers. Chapter 3, Section 3.1.2.1, discusses the current status of this standard. Sources of nonradiological air pollutants at the proposed repository could include fugitive dust emissions from land disturbances, excavated rock handling, and concrete batch plant operations and emissions from fossil-fuel consumption.

8.2.2.1.1 *Nonradiological Air Quality*

The construction, operation and monitoring, and closure of the proposed Yucca Mountain Repository for Inventory Module 1 or 2 would result in increased releases of criteria pollutants (nitrogen dioxide, sulfur dioxide, carbon monoxide, and particulate matter) and cristobalite as described in the following sections. The types of activities producing these releases would be the same as those described for the Proposed Action (see Chapter 4, Section 4.1.2).

Construction. The repository construction phase for Inventory Module 1 or 2 would produce the same levels of gaseous pollutants and cristobalite but slightly higher air concentrations of particulate matter, as

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listed in Table 8-7. The air concentrations would still be small fractions of the applicable regulatory limits.

Table 8-7. Estimated construction phase concentrations of criteria pollutants and cristobalite (micrograms per cubic meter).[a]

Pollutant	Averaging time	Regulatory limit[b]	Maximum concentration[c,d,e] Higher-temperature	Maximum concentration[c,d,e] Lower-temperature	Percent of regulatory limit[e] Higher-temperature	Percent of regulatory limit[e] Lower-temperature
			Proposed Action			
Nitrogen dioxide	Annual	100	0.40	0.41 - 0.42	0.41	0.41 - 0.42
Sulfur dioxide	Annual	80	0.10	0.10	0.13	0.13
	24-hour	365	1.3	1.3	0.36	0.36
	3-hour	1,300	8.5	8.6 - 8.7	0.66	0.66 - 0.67
Carbon monoxide[f]	8-hour	10,000	4.2	4.3 - 4.4	0.041	0.042 - 0.043
	1-hour	40,000	29	29 - 30	0.072	0.073 - 0.075
PM_{10} ($PM_{2.5}$)[f]	Annual	50 (15)	0.69	0.74 - 0.94	1.4	1.5 - 1.9
	24-hour	150 (65)	6.5	7.0 - 8.4	4.3	4.7 - 5.6
Cristobalite	Annual[g]	10[g]	0.018	0.017 - 0.018	0.18	0.17 - 0.18
			Inventory Module 1 or 2			
Nitrogen dioxide	Annual	100	0.40	0.41 - 0.42	0.40	0.41 - 0.42
Sulfur dioxide	Annual	80	0.10	0.10	0.13	0.13
	24-hour	365	1.3	1.3	0.36	0.36
	3-hour	1,300	8.5	8.6 - 8.7	0.66	0.66 - 0.67
Carbon monoxide	8-hour	10,000	4.2	4.3 - 4.4	0.041	0.043
	1-hour	40,000	29	29 - 30	0.072	0.073 - 0.075
PM_{10} ($PM_{2.5}$)[f]	Annual	50 (15)	0.81	0.85 - 1.1	1.6	1.7 - 2.1
	24-hour	150 (65)	7.1	7.4 - 8.9	4.7	4.9 - 5.8
Cristobalite	Annual[g]	10[g]	0.018	0.017 - 0.018	0.18	0.17-0.18

a. Source: Appendix G, Section G.1.4.
b. Regulatory limits for criteria pollutants from 40 CFR 50.4 through 50.11 and Nevada Administrative Code 445B.391 (see Chapter 3, Table 3-5).
c. Sum of highest concentrations at the accessible land withdrawal boundary, regardless of direction.
d. Source: Chapter 4, Section 4.1.2 and Appendix G, Section G.1.4.
e. Numbers are rounded to two significant figures; therefore, the percent of regulatory limit might not equal the percent calculated from the numbers listed in the table.
f. Data on $PM_{2.5}$ not being collected at time of analysis. However, overall PM_{10} numbers are well below standard for both.
g. There are no regulatory limits for public exposure to cristobalite, a form of crystalline silica. An Environmental Protection Agency health assessment (DIRS 103243-EPA 1996, all) states that the risk of silicosis is less than 1 percent for a cumulative exposure to 1,000 micrograms per cubic meter-year. Using a 70-year lifetime, an approximate annual average concentration of 10 micrograms per cubic meter was established as a benchmark for comparison.

Operation and Monitoring. Table 8-8 lists estimated air quality impacts from criteria pollutants and cristobalite for Inventory Module 1 or 2. The concentrations in this table are for the period of continuing surface and subsurface development and emplacement activities. During the subsequent monitoring and maintenance activities these concentrations would decrease considerably. All concentrations are comparable to those produced under the Proposed Action. All concentrations would be small fractions of the applicable regulatory limits for Module 1 or 2. Because the development of the emplacement drifts for Module 1 or 2 would take additional time compared to the Proposed Action, these releases of criteria pollutants would occur over a longer period than those from the Proposed Action. In general, the values in Table 8-8 for operation and monitoring are smaller than the values in Table 8-7 for construction because there would be more land surface disturbance during construction.

Closure. Continuing the closure of the repository for either Inventory Module 1 or 2 would produce comparable, but slightly lower, concentrations of gaseous pollutants, particulate matter, and cristobalite than those estimated for the Proposed Action. The concentrations would still be small fractions of the applicable regulatory limits (see Table 8-9). With Inventory Module 1 or 2, the amount of backfill required to close the ramps, main tunnels, and ventilation shafts would be larger than that for the Proposed Action, and the size of the excavated rock pile to reclaim would be larger. However, the

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Table 8-8. Estimated operation and monitoring phase concentrations of criteria pollutants and cristobalite (micrograms per cubic meter).[a]

Pollutant	Averaging time	Regulatory limit[b]	Maximum concentration[c,d,e] Higher-temperature	Maximum concentration[c,d,e] Lower-temperature	Percent of regulatory limit[e] Higher-temperature	Percent of regulatory limit[e] Lower-temperature
Proposed Action						
Nitrogen dioxide	Annual	100	0.28	0.28 - 0.31	0.28	0.29 - 0.32
Sulfur dioxide	Annual	80	0.089	0.089 - 0.092	0.11	0.11 - 0.12
	24-hour	365	1.2	1.2	0.33	0.34
	3-hour	1,300	7.8	7.9 - 8.0	0.60	0.61 - 0.62
Carbon monoxide	8-hour	10,000	2.7	2.7 - 3.0	0.026	0.027 - 0.029
	1-hour	40,000	19	19 - 21	0.048	0.049 - 0.052
PM_{10} ($PM_{2.5}$)[f]	Annual	50 (15)	0.080	0.10 - 0.19	0.16	0.20 - 0.39
	24-hour	150 (65)	0.97	1.3 - 2.3	0.65	0.87 - 1.6
Cristobalite	Annual[g]	10[g]	0.0093	0.009 - 0.017	0.093	0.091 - 0.17
Inventory Module 1 or 2						
Nitrogen dioxide	Annual	100	0.28	0.29 - 0.32	0.28	0.29 - 0.32
Sulfur dioxide	Annual	80	0.089	0.090 - 0.093	0.11	0.12
	24-hour	365	1.2	1.2 - 1.3	0.34	0.34
	3-hour	1,300	7.9	7.9 - 8.1	0.60	0.61 - 0.62
Carbon monoxide	8-hour	10,000	2.6	2.7 - 2.9	0.026	0.026 - 0.029
	1-hour	40,000	19	19 - 21	0.047	0.048 - 0.052
PM_{10} ($PM_{2.5}$)[f]	Annual	50 (15)	0.18	0.18 - 0.23	0.37	0.37 - 0.46
	24-hour	150 (65)	2.6	2.6 - 3.0	1.7	1.7 - 2.0
Cristobalite	Annual[g]	10[g]	0.011	0.010 - 0.016	0.11	0.10 - 0.16

a. Source: Appendix G, Section G.1.5.
b. Regulatory limits for criteria pollutants from 40 CFR 50.4 through 50.11, and Nevada Administrative Code 445B.391 (see Chapter 3, Table 3-5).
c. Sum of highest concentrations at accessible land withdrawal boundary, regardless of direction.
d. Source: Chapter 4, Section 4.1.2 and Appendix G, Section G.1.5.
e. Numbers are rounded to two significant figures; therefore, the percent of regulatory limit might not equal the percent calculated from the numbers listed in the table.
f. Data on $PM_{2.5}$ not being collected at time of analysis. However, overall PM_{10} numbers are well below standard for both.
g. There are no regulatory limits for public exposure to cristobalite, a form of crystalline silica. An Environmental Protection Agency health assessment (DIRS 103243-EPA 1996, all) states that the risk of silicosis is less than 1 percent for a cumulative exposure to 1,000 micrograms per cubic meter-year. Using a 70-year lifetime, an approximate annual average concentration of 10 micrograms per cubic meter was established as a benchmark for comparison.

duration of the closure period for Inventory Module 1 or 2 would increase over that of the Proposed Action, resulting in minor changes in the air concentrations between the Proposed Action and Inventory Module 1 or 2.

8.2.2.1.2 *Radiological Air Quality*

Inventory Module 1 or 2 would require more subsurface excavation and a longer closure phase leading to increased radon releases compared to the Proposed Action. The increased quantity of spent nuclear fuel that repository facilities would receive and package would also result in additional releases of krypton-85 from failed spent nuclear fuel cladding but, as for the Proposed Action, naturally occurring radon-222 and its radioactive decay products would still be the dominant dose contributors.

The following paragraphs discuss the estimated radiological air quality impacts in terms of the potential radiation dose to members of the public and workers for the construction, operation and monitoring, and closure phases of Inventory Module 1 or 2. For these estimates, workers exposed through the air pathway would be noninvolved workers.

Construction. Table 8-10 lists estimated doses to members of the public and workers for the construction phase. These values resulting from radon releases during the 5-year construction phase

Table 8-9. Estimated closure phase concentrations of criteria pollutants and cristobalite (micrograms per cubic meter).[a]

Pollutant	Averaging time	Regulatory limit[b]	Proposed Action: Maximum concentration[c,d,e] Higher-temperature	Maximum concentration[c,d,e] Lower-temperature	Percent of regulatory limit[d] Higher-temperature	Percent of regulatory limit[d] Lower-temperature
Nitrogen dioxide	Annual	100	0.54	0.54	0.54	0.54 - 0.55
Sulfur dioxide	Annual	80	0.11	0.11	0.15	0.15
	24-hour	365	1.4	1.4	0.38	0.38
	3-hour	1,300	9.3	9.3	0.71	0.71 - 0.72
Carbon monoxide	8-hour	10,000	4.7	4.7	0.045	0.045 - 0.046
	1-hour	40,000	31	31	0.078	0.078
PM_{10} ($PM_{2.5}$)[f]	Annual	50 (15)	0.38	0.34 - 0.37	0.76	0.67 - 0.73
	24-hour	150 (65)	5.5	5.2 - 5.4	3.6	3.4 - 3.6
Cristobalite	Annual[g]	10[g]	0.012	0.0089 - 0.0095	0.12	0.089 - 0.098
			Inventory Module 1 or 2			
Nitrogen dioxide	Annual	100	0.51	0.48 - 0.49	0.52	0.49
Sulfur dioxide	Annual	80	0.11	0.11	0.14	0.14
	24-hour	365	1.4	1.4	0.38	0.37
	3-hour	1,300	9.1	9.0	0.70	0.69
Carbon monoxide	8-hour	10,000	4.4	4.2 - 4.3	0.043	0.041 - 0.042
	1-hour	40,000	30	28 - 29	0.075	0.071 - 0.072
PM_{10} ($PM_{2.5}$)[f]	Annual	50 (15)	0.40	0.32 - 0.35	0.079	0.65 - 0.69
	24-hour	150 (65)	5.6	5.1 - 5.2	3.7	3.4 - 3.5
Cristobalite	Annual[g]	10[g]	0.013	0.010 - 0.013	0.13	0.10 - 0.13

a. Source: Appendix G, Section G.1.6.
b. Regulatory limits for criteria pollutants from 40 CFR 50.4 through 50.11 and Nevada Administrative Code 445B.391 (see Chapter 3, Table 3-5).
c. Sum of highest concentrations at accessible land withdrawal boundary, regardless of direction.
d. Source: Chapter 4, Section 4.1.2 and Appendix G, Section G.1.6.
e. Numbers are rounded to two significant figures; therefore, the percent of regulatory limit might not equal the percent calculated from the numbers listed in the table.
f. Data on $PM_{2.5}$ not being collected at time of analysis. However, overall PM_{10} numbers are well below standard for both.
g. There are no regulatory limits for public exposure to cristobalite, a form of crystalline silica. An Environmental Protection Agency health assessment (DIRS 103243-EPA 1996, all) states that the risk of silicosis is less than 1 percent for a cumulative exposure to 1,000 micrograms per cubic meter-year. Using a 70-year lifetime, an approximate annual average concentration of 10 micrograms per cubic meter was established as a benchmark for comparison.

would be similar to those for the Proposed Action because the subsurface volume excavated would be about the same.

Operation and Monitoring. The doses from krypton-85 from receipt and packaging activities during operation and monitoring would be very low. Dose to the public would be only a fraction (0.00003 or less) of the dose from naturally occurring radon-222 and its radioactive decay products, as discussed below. Similarly, the dose to Yucca Mountain workers from krypton-85 would be a fraction (0.00001 or less) of the dose to those workers from radon-222. The annual dose from krypton-85 would be the same as that for the Proposed Action, but would occur for 38 years of spent nuclear fuel handling activities rather than 24 years.

Table 8-11 and Table 8-12 list doses to individuals and populations for operation and monitoring, respectively. In all cases, naturally occurring radon-222 would be the dominant contributor to the doses, which would increase because of the larger repository required for Inventory Module 1 or 2. Average annual doses would be higher to members of the public and higher to noninvolved workers during the 38 years of development and emplacement activities when the South Portal would be open and used for exhaust ventilation. The analysis estimated collective doses for public and worker populations for the 100 to 338 years for operation and monitoring, including the 38 years of development and emplacement activities and 62 to 300 years of monitoring and maintenance activities. The dose to the maximally exposed member of the public is for 38 years of operations and 32 years of monitoring (that is, a 70-year

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Table 8-10. Estimated radiation doses to maximally exposed individuals and populations from subsurface radon-222 releases during initial construction period.[a,b,c]

Impact	Operating mode			
	Higher-temperature		Lower-temperature	
	Total	Maximum annual	Total	Maximum annual
	Proposed Action			
Dose to public				
Offsite MEI[d] (millirem)	1.7	0.43	1.7 - 2.0	0.43 - 0.53
80-kilometer population[e] (person-rem)	33	8.4	33 - 40	8.4 - 10
Dose to noninvolved (surface) workers				
Maximally exposed noninvolved worker[f] (millirem)	7.5	2.0	7.5 - 9.0	1.9 - 2.3
Yucca Mountain noninvolved worker population[g] (person-rem)	0.41	0.10	0.41 - 0.48	0.10 - 0.13
Nevada Test Site noninvolved worker population[h] (person-rem)	0.0013	0.00032	0.0013 - 0.0015	0.00032 - 0.00039
	Inventory Module 1 or 2			
Dose to public				
Offsite MEI (millirem)	1.7	0.43	2.0	0.52 - 0.53
80-kilometer population (person-rem)	33	8.4	39 - 40	10
Dose to noninvolved (surface) workers				
Maximally exposed noninvolved worker (millirem)	7.5	2.0	8.8 - 9.0	2.3
Yucca Mountain noninvolved worker population (person-rem)	0.41	0.10	0.47 - 0.49	0.12 - 0.13
Nevada Test Site noninvolved worker population (person-rem)	0.0013	0.00032	0.0015	0.00038 - 0.00039

a. Source: Appendix G, Section G.2.
b. Numbers are rounded to two significant figures.
c. Annual values are for the maximum year during the construction phase.
d. MEI = maximally exposed individual; public MEI location would be at the southern boundary of the land withdrawal area.
e. The population includes about 76,000 individuals within 80 kilometers (50 miles) of the repository (see Chapter 3, Section 3.1.8).
f. Maximally exposed noninvolved worker would be in the South Portal Development Area.
g. Includes noninvolved workers at the North Portal Operations Area and South Portal Development Area.
h. DOE workers at the Nevada Test Site [about 6,600 workers (DIRS 101811-DOE 1996, p. 5-14) 50 kilometers (30 miles) east-southeast near Mercury, Nevada].

Table 8-11. Estimated radiation doses to maximally exposed individuals and populations during operations activities.[a,b,c,d]

Impact	Operating mode			
	Higher-temperature		Lower-temperature	
	Total	Maximum annual	Total	Maximum annual
	Proposed Action			
Dose to public				
Offsite MEI[e] (millirem)	12	0.73	17 - 43	1.0 - 1.3
80-kilometer population[f] (person-rem)	230	14	320 - 830	20 - 26
Dose to noninvolved (surface) workers				
Maximally exposed noninvolved worker[g] (millirem)	30	2.0	39 - 42	2.8 - 3.0
Yucca Mountain noninvolved worker population[h] (person-rem)	1.2	0.081	1.8 - 1.9	0.12 - 0.13
Nevada Test Site noninvolved worker population[i] (person-rem)	0.011	0.00063	0.015 - 0.043	0.00090 - 0.0012
	Inventory Module 1 or 2			
Dose to public				
Offsite MEI (millirem)	22	0.94	31 - 66	1.3 - 2.2
80-kilometer population (person-rem)	430	18	600 - 1,300	26 - 42
Dose to noninvolved (surface) workers				
Maximally exposed noninvolved worker (millirem)	45	2.0	62 - 95	2.8 - 4.6
Yucca Mountain noninvolved worker population (person-rem)	1.8	0.081	2.5 - 4.1	0.11 - 0.2
Nevada Test Site noninvolved worker population (person-rem)	0.02	0.00085	0.028 - 0.063	0.0012 - 0.002

a. Source: Appendix G, Section G.2.
b. Numbers are rounded to two significant figures.
c. For Inventory Module 1 or 2, the operation and monitoring phase would last 100 years for the higher-temperature operating mode and 163 to 338 years for the lower-temperature operating mode.
d. Maximum annual dose occurs during the last year of development, when repository would be largest and South Portal would still be used for exhaust ventilation.
e. MEI = maximally exposed and individual; at the southern boundary of the land withdrawal area.
f. The population includes about 76,000 individuals within 80 kilometers (50 miles) of the repository (see Chapter 3, Section 3.1.8).
g. Maximally exposed noninvolved worker would be in the South Portal Development Area.
h. Includes noninvolved workers at the North Portal Operations Area and South Portal Development Area.
i. DOE workers at the Nevada Test Site [6,600 workers (DIRS 101811-DOE 1996, p. 5-14) 50 kilometers (30 miles) east-southeast near Mercury, Nevada].

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Table 8-12. Estimated radiation doses to maximally exposed individuals and populations during monitoring activities.[a,b,c,d]

Impact	Operating mode			
	Higher-temperature		Lower-temperature	
	Total	Maximum annual	Total	Maximum annual
	Proposed Action			
Dose to public				
Offsite MEI[e] (millirem)	29	0.41	30 - 62	0.59 - 0.89
80-kilometer population[f] (person-rem)	600	8	1,500 - 3,500	11 - 17
Dose to noninvolved (surface) workers				
Maximally exposed noninvolved worker[g] (millirem)	0.096	0.0019	0.16 - 0.33	0.0011 - 0.0067
Yucca Mountain noninvolved worker population[h] (person-rem)	0.0091	0.0013	0.0031 - 0.05	0.000034 - 0.0057
Nevada Test Site noninvolved worker population[i] (person-rem)	0.033	0.00044	0.083 - 0.019	0.00021 - 0.00094
	Inventory Module 1 or 2			
Dose to public				
Offsite MEI (millirem)	39	0.62	20 - 100	0.29 - 1.4
80-kilometer population (person-rem)	740	12	2,200 - 5,400	5.6 - 28
Dose to noninvolved (surface) workers				
Maximally exposed noninvolved worker (millirem)	0.22	0.0043	0.33 - 0.54	0.0022 - 0.011
Yucca Mountain noninvolved worker population (person-rem)	0.025	0.0044	0.067 - 0.1	0.000075 - 0.0091
Nevada Test Site noninvolved worker population (person-rem)	0.041	0.00066	0.12 - 0.3	0.00031 - 0.0015

a. Source: Appendix G, Section G.2.
b. Numbers are rounded to two significant figures.
c, For Inventory Module 1 or 2, the operation and monitoring phase would last 100 years for the higher-temperature operating mode and 163 to 338 years for the lower-temperature operating mode.
d. Maximum annual dose occurs during the last year of development, when repository would be largest and South Portal would still be used for exhaust ventilation.
e. MEI = maximally exposed individual; at the southern boundary of the land withdrawal area.
f. The population includes about 76,000 individuals within 80 kilometers (50 miles) of the repository (see Chapter 3, Section 3.1.8).
g. Maximally exposed noninvolved worker would be in the South Portal Development Area.
h. Includes noninvolved workers at the North Portal Operations Area and South Portal Development Area.
i. DOE workers at the Nevada Test Site [6,600 workers (DIRS 101811-DOE 1996, p. 5-14) 50 kilometers (30 miles) east-southeast near Mercury, Nevada].

lifetime). The dose to the maximally exposed noninvolved worker is for 50 years at the South Portal during development, emplacement, and monitoring activities.

Closure. Table 8-13 lists estimated doses to populations and maximally exposed individuals during the closure phase. Radiation doses would increase over those for the Proposed Action not only because of the larger excavated volume but also the longer time required for closure (12 to 23 years) in comparison to 10 to 17 years.

Summary. Based on the analysis of radiological air quality impacts from repository construction, operation and monitoring, and closure for Inventory Module 1 or 2, the estimated maximum annual dose to the maximally exposed individual member of the public would be 0.99 millirem for the lower-temperature operating mode during development and emplacement activities in the operation and monitoring phase. DOE compared the estimated annual dose to the Preclosure Public Health and Environmental Standard found at 10 CFR 63.204, which is 15 millirem per year to a member of the public. The dose would be about 6.6 percent of this standard. The radiation dose is 0.3 percent of the annual 340-millirem natural background dose to individuals in Amargosa Valley. Section 8.2.7 discusses human health impacts to the public that could result from radiation exposures during construction, operation and monitoring, and closure for Inventory Module 1 or 2.

8.2.2.2 Cumulative Impacts from Inventory Module 1 or 2 and Other Federal, Non-Federal, and Private Actions

This section addresses potential nonradiological and radiological cumulative impacts to air quality from activities at the repository for the Proposed Action or Inventory Module 1 or 2 and other Federal,

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Table 8-13. Estimated radiation doses to maximally exposed individuals and populations from radon-222 releases during closure phase.[a,b,c]

Impact	Operating mode: Higher-temperature Total	Higher-temperature Maximum annual	Lower-temperature Total	Lower-temperature Maximum annual
	Proposed Action			
Dose to public				
MEI[d] (millirem)	3.0	0.39	4.3 - 9.4	0.57 - 0.87
80-kilometer population[e] (person-rem)	57	7.4	83 - 180	10 - 16
Dose to noninvolved (surface) workers				
Maximally exposed noninvolved (surface) worker[f] (millirem)	0.014	0.0018	0.024 - 0.070	0.0030 - 0.0063
Yucca Mountain noninvolved (surface) worker population[g] (person-rem)	0.0040	0.00052	0.0070 - 0.015	0.00088 - 0.0014
Nevada Test Site noninvolved worker population[h] (person-rem)	0.0031	0.00041	0.0046 - 0.0099	0.00058 - 0.00089
	Inventory Module 1 or 2			
Dose to public				
MEI (millirem)	4.9	0.60	8.5 - 19	0.86 - 1.4
80-kilometer population (person-rem)	95	11	160 - 360	16 - 26
Dose to noninvolved (surface) workers				
Maximally exposed noninvolved (surface) worker (millirem)	0.034	0.0040	0.063 - 0.14	0 - 0.010
Yucca Mountain noninvolved (surface) worker population (person-rem)	0.012	0.0013	0.015 - 0.026	0.0014 - 0.0019
Nevada Test Site noninvolved worker population (person-rem)	0.0052	0.00061	0.0090 - 0.020	0.00088 - 0.00015

a. Source: Appendix G, Section G-2.
b. Numbers are rounded to two significant figures.
c. The closure phase would last 10 to 7 years for the Proposed Action and 12 to 23 years for Inventory Module 1 or 2.
d. MEI = maximally exposed individual; at the southern boundary of the land withdrawal area.
e. The population includes about 76,000 individuals within 80 kilometers (50 miles) of the repository (see Chapter 3, Section 3.1.8).
f. Maximally exposed noninvolved worker would be in the South Portal Development Area.
g. Includes noninvolved workers at the North Portal Operations Area and South Portal Development Area.
h. DOE workers at the Nevada Test Site [6,600 workers (DIRS 101811-DOE 1996, p. 5-14) 50 kilometers (30 miles) east-southeast near Mercury, Nevada].

non-Federal, and private actions that would coincide with repository operations and potentially affect the air quality within the geographic boundaries of repository air quality impacts.

To identify and quantify potential cumulative impacts on air resources from other actions, the Department used a 50-mile (80-kilometer) radius around the proposed repository as the region of influence. However, because of the distances involved and the dispersion afforded by distance and different wind directions, the potential for overlap of plumes from multiple actions would be greatest for those actions that are in close proximity to each other (that is, a few miles). Beyond that, the degree of plume overlap is less certain and indeed may not exist.

8.2.2.2.1 *Nonradiological Air Quality*

Construction, operation and monitoring, and closure of the proposed Yucca Mountain Repository would have very small impacts on regional air quality for the Proposed Action or for Inventory Module 1 or 2. Annual average concentrations of criteria pollutants at the land withdrawal boundary would be 1 percent or less of applicable regulatory limits except for PM_{10}, which the analysis estimated would be as much as 6.5 percent of the regulatory limit at the land withdrawal boundary. This estimate does not consider standard dust suppression activities (such as wetting), so actual concentrations probably would be much lower.

DOE has monitored particulate matter concentrations in the Yucca Mountain region since 1989; gaseous criteria pollutants were monitored from October 1991 through September 1995. Concentrations were well below applicable National Ambient Air Quality Standards (see Chapter 3, Section 3.1.2.1). In 1990, DOE also measured ambient air quality in several Nevada Test Site areas for short-term concentrations of sulfur dioxide, carbon monoxide, and PM_{10} (DIRS 101811-DOE 1996, Volume I, pp. 4-146 and 4-148).

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The measurements were all lower than the applicable short-term (1-hour, 3-hour, 8-hour, and 24-hour) limits.

Pollutant concentrations related to Nevada Test Site activities would be well below ambient air quality standards and would not increase ambient pollutant concentrations above standards in Nye County (DIRS 101811-DOE 1996, Volume I, p. 4-146). Therefore, DOE expects the cumulative impacts from proposed repository and Nevada Test Site operations to be very small.

Other actions discussed in Section 8.1 would be unlikely to have cumulative impacts with the repository because they are sufficiently far away that plumes would have limited potential for overlap. Further, the responsible agencies would take measures for each action to minimize regional air impacts.

Repository activities would have no effect on air quality in the Las Vegas Valley air basin, which is a nonattainment area for carbon monoxide and PM_{10}, because the Las Vegas Valley air basin lies approximately 120 kilometers (75 miles) southeast of the proposed repository site.

8.2.2.2.2 *Radiological Air Quality*

Past activities at the Nevada Test Site are responsible for the seepage of radioactive gases from underground testing areas and slightly increased krypton-85 levels on Pahute Mesa in the northwest corner of the Nevada Test Site (see Figure 8-2). Some radioactivity on the site is attributable to the resuspension of soils contaminated from past aboveground nuclear weapons testing (DIRS 101811-DOE 1996, Volume I, p. 4-149). Current Nevada Test Site defense program activities have not resulted in detectable offsite levels of radioactivity. As discussed in Chapter 3, Section 3.1.8.2, estimated radiation doses to the public during 1999 were 0.12 millirem to the maximally exposed individual [a hypothetical resident of Springdale, Nevada, which is about 14 kilometers (19 miles) north of Beatty (see Figure 8-2)] and 0.38 person-rem to the population within 80 kilometers (50 miles) of Nevada Test Site airborne emission sources (DIRS 146592-Black and Townsend 1998, p. 7-1). The radiation dose estimates from repository construction, operation and monitoring, and closure (see Tables 8-10, 8-11, 8-12, and 8-13) would add to these estimates assuming the exposed individuals and population were the same (they are not). Conservatively adding the 1999 maximally exposed individual dose from the Nevada Test Site to the highest estimated average annual dose to the maximally exposed individual from repository operations (hypothetical individual located at the southern border of the land withdrawal area) (2.2 millirem) resulted in a cumulative dose of 2.3 millirem. DOE compared the estimated annual dose to the Preclosure Public Health and Environmental Standard found at 10 CFR 63.204, which is 15 millirem per year to a member of the public. The dose would be about 15 percent of this standard. This dose would also represent 0.68 percent of the annual 340-millirem natural background radiation dose to individuals in Amargosa Valley. Conservatively adding the 1999 Nevada Test Site and highest estimated annual repository population dose (42 person-rem) results in a cumulative dose of 42 person-rem. No latent cancer fatalities to the population would be expected from this cumulative exposure (see Section 8.2.7).

Chapter 3 discusses potential radiological doses from past weapons testing at the Nevada Test Site. Residents who were present during the periods when such testing (in particular, atmospheric weapons testing from the 1950s to the early 1960s) occurred could have received as much as 5 rem to the thyroid gland from iodine-131 releases. Using a tissue weighting factor of 0.03 as specified in International Commission on Radiological Protection Publication 26 (DIRS 101075-ICRP 1977, all) this equates to an effective dose equivalent of about 150 millirem. Because of the length of time since atmospheric weapons testing ended, essentially all of this dose has already occurred. This dose would apply only to those residents who lived in the region of influence during the period of atmospheric weapons testing. DOE has not added this dose to the maximally exposed individual dose, but has included this information here so long-term residents in the region of influence can evaluate their potential for impacts from past nuclear weapons testing. (DOE has also included this information in the air quality portion of Table 8-60.)

The only other activity identified in the 80-kilometer (50-mile)-radius region of influence that could affect radiological air quality is a low-level radioactive disposal site near Beatty, Nevada, which was officially closed on January 1, 1993. The physical work of a State-approved Stabilization and Closure Plan ended in July 1994. Custodianship of the site has been transferred to the State of Nevada. Monitoring is continuing at the site to ensure that any radioactive material releases to the air continue to be low (DIRS 102171-NSHD 1999, Section on the Bureau of Health Protection Services).

8.2.3 HYDROLOGY

8.2.3.1 Surface Water

Potential impacts to surface waters from the Proposed Action would be relatively minor and limited to the immediate vicinity of land disturbances associated with the action (see Chapter 4, Section 4.1.3.2, and the floodplain/wetlands assessment in Appendix L). Surface-water impacts of primary concern would include the following:

- Introduction and movement of contaminants
- Changes to runoff or infiltration rates
- Alterations of natural drainage

This section addresses these impact areas in a discussion of possible increases or other changes that could occur as a result of the emplacement of Inventory Module 1 or 2. To be cumulative, other Federal, non-Federal, or private action effects would have to occur in the immediate area because of the transient nature of the surface water from the repository (that is, stormwater runoff). No currently identified actions have met this criterion.

Introduction and Movement of Contaminants

For Inventory Module 1 or 2, there would be essentially no change in the potential for soil contamination during the construction, operation and monitoring, and closure phases. There would be no change in the types of contaminants present nor would there be changes in operations that would make spills or releases more likely. Similarly, there would be no change in the threat of flooding to cause contaminant releases beyond that described for the Proposed Action.

Changes to Runoff or Infiltration Rates

Compared to the estimated area of land disturbed under the Proposed Action, Inventory Module 1 or 2 would require the disturbance of additional land for the corresponding repository operating mode (see Table 8-4). A maximum of about 5.5 square kilometers (1,400 acres) of land would be newly disturbed for Module 1 or 2 for the lower-temperature mode if surface aging was included. This increase in disturbed land would still be a relatively small portion of the natural drainage areas and would make little difference in the amount of water that soaked into the ground or reached the intermittently flowing drainage channels. Disturbed areas not covered by structures would slowly return to conditions more similar to those of the surrounding undisturbed ground.

Alterations of Natural Drainage

No additional actions or land disturbances associated with Inventory Module 1 or 2 would involve a potential to alter noteworthy natural drainage channels in the area. The excavated rock pile and its increased size for Module 1 or 2 would be in an area that would obstruct a very small portion of overland drainage. Potential impacts to floodplains would be the same as those described for the Proposed Action (see Chapter 4, Section 4.1.3.3). The construction, operation, and maintenance of a rail line, roadways, and bridges in the Yucca Mountain vicinity could affect the 100- and 500-year floodplains of Fortymile Wash, Busted Butte Wash, Drill Hole Wash, and Midway Valley Wash at Yucca Mountain. The floodplains affected and the extent of activities in the floodplains would depend on which routes DOE selected. Appendix L contains a floodplain/wetlands assessment that describes the actions DOE could take to construct, operate, and maintain a branch rail line or highway route in the Yucca Mountain vicinity.

8.2.3.2 Groundwater

8.2.3.2.1 *Inventory Module 1 or 2 Impacts*

Potential groundwater impacts would be related to the following:

- The potential for a change in infiltration rates that could increase the amount of water in the unsaturated zone and adversely affect the performance of waste containment in the repository, or decrease the amount of recharge to the aquifer
- The potential for contaminants to migrate to the unsaturated or saturated groundwater zones during the active life of the repository
- The potential for water demands associated with the repository to deplete groundwater resources to an extent that could affect downgradient groundwater use or users

Changes to Infiltration and Aquifer Recharge. If DOE emplaced Inventory Module 1 or 2, changes related to infiltration and recharge rates would be limited to three areas: a possible increase in the size of the excavated rock pile, an increase in the number of ventilation shaft operations areas, and an extended scope for subsurface activities. The following paragraphs discuss these items.

Additional land disturbance anticipated during the operation and monitoring phase would be the continued growth of the excavated rock pile. Depending on the repository operating mode, this could involve as much as about 0.5 square kilometer (120 acres) of additional land over that required for the Proposed Action (see Table 8-4). Although the excavated rock pile could have different infiltration rates than undisturbed ground, it probably would not be a recharge location because of the extended depth of unconsolidated material, nor would it be likely to cause a large change in the amount of water that would otherwise reach recharge areas such as drainage channels.

Increased land disturbance would result from the additional ventilation shaft operation areas and the access roads that would be required as the repository footprint size increased to accommodate the Module 1 or 2 inventory. Depending on the repository operating mode, this could involve an additional 0.3 to 0.47 square kilometer (74 to 120 acres) of land disturbance over that required for these elements of the Proposed Action (see Table 8-4). These areas of disturbance would be primarily on steeper terrain, uphill from the portal areas, where unconsolidated material is likely thin and where disturbances could expose fractured bedrock. Infiltration rates could be increased notably in such areas as a result. However, much of the disturbed area would be capped with road material or equipment pads, and the amount of disturbed land would still be small in comparison to the surrounding undisturbed area.

Underground activities and their associated potential to contribute to the deep infiltration of water would be basically the same as those described for the Proposed Action, except emplacement drift construction would take an estimated 36 years to complete with either Inventory Module 1 or 2, compared to 22 years for the Proposed Action (see Table 8-3). As described for the Proposed Action, the quantities of water in the subsurface not removed to the surface by ventilation or pumping and thus available for infiltration would be small and primarily limited to the duration of drift development when the largest quantities of water would be used in the subsurface for dust control.

Potential for Contaminant Migration to Groundwater Zones. Neither Inventory Module 1 nor 2 would involve additional actions likely to increase the potential for contaminant releases to the environment. The only possible exception to this could be the extended period of subsurface excavation activities to accommodate the additional inventory. However, this exception would be an extension of activities with minimal potential to involve substantial contaminant releases.

Potential to Deplete Groundwater Resources. Anticipated annual water demand for Inventory Module 1 or 2 would be the same or very similar to that projected for the Proposed Action. Table 8-14 summarizes estimated annual water demands for both the Proposed Action and Inventory Module 1 or 2. The table indicates no notable change in water demand during construction.

Table 8-14. Estimated annual water demand (acre-feet)[a] for the Proposed Action and Inventory Module 1 or 2.

	Water demand (acre-feet/year)[a]		
		Operating mode	
Phase	Duration (years)	Higher-temperature	Lower-temperature
	Proposed Action		
Construction	5	160	190 to 210
Operation and monitoring (by activity)			
Emplacement and development activities			
Combined emplacement and development	22	230	250 to 290
Subsequent emplacement or aging only[b]	2 or 28	180	90 to 190
Monitoring activities			
Initial decontamination	3	220	200 to 230
Subsequent monitoring/caretaking	73 to 297	6	3 to 6
Closure	10 to 17	81	70 to 84
	Inventory Module 1 or 2		
Construction	5	160	190 to 210
Operation and monitoring (by activity)			
Emplacement and development activities			
Combined emplacement and development	36	250	240 to 320
Subsequent emplacement only[b]	2 or 15	180	90 to 190
Monitoring activities			
Initial decontamination	3	220	200 to 230
Subsequent monitoring/caretaking	59 to 297	6	4 to 6
Closure	12 to 23	83	73 to 91

a. To convert acre-feet to cubic meters, multiply by 1,233.49.
b. Unless surface aging is involved, the period during which development was complete and only emplacement being conducted would last 2 years. This higher duration listed is applicable only to the lower-temperature repository operating mode that includes surface aging.

Projected annual water demand during emplacement and development activities of the operation and monitoring phase (as listed in Table 8-14) would be very similar, but generally a little higher under Inventory Module 1 or 2. However, the difference in total water demand would be greater when the change in the duration of the annual demand is taken into consideration. That is, this phase of repository activities, which would have the highest annual water demand, is extended from 22 to 36 years with the Module 1 or 2 inventory. On an annual basis, water demand would increase no more than 4 to 10 percent over that for the Proposed Action but, during the entire 36-year period, Inventory Module 1 or 2 would result in an increased water demand by as much as about 80 percent, depending on the repository operating mode.

Projected annual water demand during monitoring activities of the operation and monitoring phase would be basically the same under either the Proposed Action or Inventory Module 1 or 2. In either case, the relatively high demands listed in Table 8-14 would last only about 3 years during surface facility decontamination, after which the annual demand would drop drastically for the remainder of this long-duration activity. The closure phase for Module 1 or 2 shows there would be only a slight increase in projected annual water demand in comparison to the Proposed Action. The fact that the duration of the closure phase would be longer under Module 1 or 2 would increase the difference on a total-phase basis, but the increases would still be minor.

Potential impacts to water resources under Inventory Module 1 or 2 would be very similar to those under the Proposed Action because the annual water demand would change little, and the best understanding of the groundwater resource is that it is replenished on an annual basis as gauged by the perennial yield of the groundwater basin. Under Module 1 or 2, the repository's annual water demand from the western two-thirds of the Jackass Flats basin would remain below the lowest estimated value for its perennial yield of [720,000 cubic meters (580 acre-feet)] (see Chapter 3, Table 3-11). See Chapter 4, Section 4.1.3.3 for more information on regional groundwater usage and demand.

8.2.3.2.2 *Cumulative Impacts from Inventory Module 1 or 2 and Other Federal, Non-Federal, and Private Actions*

Potential impacts to groundwater, as described in Chapter 4, Section 4.1.3.3, and in Section 8.2.3.2.1, for the Proposed Action and Inventory Module 1 or 2 would be small and limited to the immediate vicinity of land disturbances associated with the action. The exceptions to this would be the potential impact from water demands on groundwater resources and potential impacts from contaminants in groundwater. With these exceptions, other Federal, non-Federal, or private action effects would have to occur in the same region of influence to be cumulative with those resulting from the Proposed Action or Inventory Module 1 or 2, and no currently identified actions meet this criterion.

The remainder of this discussion addresses potential impacts to groundwater resources from water demand. Section 8.3 addresses long-term impacts of contaminants in groundwater.

The discussion of impacts to groundwater resources in Chapter 4, Section 4.1.3.3, includes ongoing water demands from Area 25 of the Nevada Test Site. Area 25 is the proposed location of the primary repository surface facilities. It is also the location of wells J-12 and J-13, which would provide water for the Proposed Action and for ongoing Nevada Test Site activities in this area. The estimated water demand for these ongoing activities is 340,000 cubic meters (280 acre-feet) a year (DIRS 103226-DOE 1998, Table 11-2, p. 11-6).

Water demand during emplacement and development activities of the operation and monitoring phase under Inventory Module 1 or 2 combined with the baseline demands from Nevada Test Site activities would exceed the lowest perennial yield estimate under the lower-temperature repository operating modes if certain features were enacted. The highest annual water demand attributed to the lower-temperature operating mode with maximum package spacing, in combination with ongoing Nevada Test Site water demands, would exceed the lowest estimate of perennial yield, but only marginally. The worst-case scenario for repository water demand (maximum spacing and surface aging under the lower-temperature operating mode) added to the Nevada Test Site demand would total about 240,000 cubic meters (600 acre-feet) per year compared to 720,000 cubic meters (580 acre-feet), the lowest estimate of perennial yield for the western two-thirds of Jackass Flats. Besides these exceptions, the combined water demands would be below the lowest estimate of perennial yield. None of the water demand estimates would approach the high estimate of perennial yield for the entire Jackass Flats hydrographic basin, which is 4.9 million cubic meters (4,000 acre-feet) (see Chapter 3, Table 3-11). Potential impacts to groundwater resources from this combined demand would be no different than those described in Chapter 4,

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Section 4.1.3.3. That is, some decline in the water level would be likely near the production wells, and water elevation decreases at the town of Amargosa Valley would probably be no more than 0.4 to 1.1 meter (1.2 to 3.6 feet) (see Section 4.1.3.3). The reduction in underflow from the Jackass Flats hydrographic area to the Amargosa Desert hydrographic area would be less than the quantity of water actually withdrawn from the upgradient area because there would probably be minor changes in groundwater flow patterns as the water level adjusted to the withdrawals. Groundwater flow models predict the reduction in underflow to the Amargosa Desert would be no higher than 160,000 to 180,000 cubic meters (130 to 150 acre-feet) per year (see Section 4.1.3.3).

The Nevada Test Site EIS (DIRS 101811-DOE 1996, pp. 3-18, 3-19, and 3-34) indicates that the potential construction and operation of a Solar Enterprise Zone facility would represent the only action that would cause water withdrawals on the Test Site to exceed past levels. That EIS estimates that this demand would be greater than the highest estimates of the basin's perennial yield. Therefore, cumulative impacts from the Solar Enterprise Zone facility are likely. DOE is considering several locations for the Solar Enterprise Zone facility, one of which is Area 25. If DOE built this facility in Area 25, it would obtain water from the Jackass Flats hydrologic area, and possibly from other hydrologic areas.

Cumulative demands on the Jackass Flats hydrographic area could have long-term impacts on water availability in the downgradient aquifers beneath the Amargosa Desert. The groundwaters in these areas are hydraulically linked, but the exact nature and extent of that link is still a matter of study and some speculation. However, the amount of water already being withdrawn in the Amargosa Desert [averaging about 17 million cubic meters (14,000 acre-feet) of water per year from 1995 through 1997 (see Chapter 3, Table 3-11)] is much greater than the quantities being considered for withdrawal from Jackass Flats. If water pumpage from Jackass Flats affected water levels in the Amargosa Desert, the impacts would be small in comparison to those caused by local pumping in that area.

A report from the Nye County Nuclear Waste Repository Office (DIRS 103099-Buqo 1999, pp. 39 to 53) provides a perspective of potential cumulative impacts with that County as the center of interest. The Nye County report evaluates impacts to all water resources potentially available in the entire county, whereas this EIS focuses principally on impacts to the Jackass Flats groundwater basin (the source of water that DOE would use for the repository) and the groundwater system that could become contaminated thousands of years in the future. Nye County reports that the potential cumulative impacts would include additive contamination as radionuclides ultimately reached the groundwater, constraints on development of groundwater due to land withdrawal, and reduction of water available for Nye County development because of use by Federal agencies (DIRS 103099-Buqo 1999, pp. 49 to 51).

8.2.4 BIOLOGICAL RESOURCES

Impacts to biological resources from Inventory Module 1 or 2 would be similar to impacts that would occur as a result of the Proposed Action evaluated in Chapter 4, Section 4.1.4. Those impacts would occur primarily as a result of site clearing, placement of material in the excavated rock pile, habitat loss, and the loss of individuals of some animal species during site clearing and from vehicle traffic.

Inventory Module 1 or 2 would require disturbing biological resources in a larger area under each thermal load scenario than would be disturbed under the Proposed Action, primarily because the excavated rock pile would be larger (Table 8-15).

Repository construction and the excavated rock pile to support Inventory Module 1 or 2 would disturb up to 5.5 square kilometers of previously undisturbed land. Disturbances would occur in areas dominated by Mojave mixed scrub and salt desert scrub land cover types. These cover types are widespread in the withdrawal area and in Nevada. This disturbed area is larger than that for the Proposed Action and would

Table 8-15. Area of land cover types in analyzed withdrawal area disturbed by construction and the excavated rock pile (square kilometers).[a,b,c]

Land cover type	Area in Nevada	Area in analyzed withdrawal area[d]	Operating mode: Higher-temperature	Operating mode: Lower- temperature
			Proposed Action	
Blackbrush	9,900	140	0.0	0 - 0.2
Creosote-bursage	15,000	300	0.6	0.6 - 0.7
Mojave mixed scrub	5,700	120	2.2	2.4 - 3.6
Sagebrush	67,000	16	0.0	0
Salt desert scrub	58,000	20	0.0	0
Previously disturbed[e]	NA[f]	4	1.5	1.5
Totals	***NA***	***600***	***4.3***	***4.5 - 6***
			Inventory Module 1 or 2	
Blackbrush	9,900	140	0.0	0 - 0.2
Creosote-bursage	15,000	300	0.6	0.6 - 0.7
Mojave mixed scrub	5,700	120	3.0	3.2 - 4.6
Sagebrush	67,000	16	0.0	0
Salt desert scrub	58,000	20	0.0	0
Previously disturbed[e]	NA	4	1.5	1.5
Totals	***NA***	***600***	***5.1***	***5.4 - 7***

a. Source: Facility diagrams from DIRS 104523-CRWMS M&O (1999, Figures 6.1.7-1, 6.1.7-2, 6.2.7-1, and 6.2.7-2; pp. 6-42, 6-43, 6-84, and 6-85) overlain on the land cover types map; DIRS 104589-CRWMS M&O (1998, p. 9 as adapted) using a Geographic Information System.
b. To convert square kilometers to acres, multiply by 247.1.
c. Totals might differ from sums of values due to rounding.
d. A small area [0.016 square kilometer (4 acres)] of the pinyon-juniper-2 land cover type occurs in the analyzed land withdrawal area, but would not be affected.
e. Estimate of land previously disturbed in support of the proposed repository.
f. NA = not applicable.

affect vegetation on approximately 1 percent of the previously undisturbed land within the land withdrawal area.

Releases of radioactive materials would not adversely affect biological resources. Routine releases would consist of noble gases, primarily krypton-85 and radon-222. These gases would not accumulate in the environment around Yucca Mountain and would result in low doses to plants or animals.

Overall impacts to biological resources from Inventory Module 1 or 2 would be very small. Species at the repository site are generally widespread throughout the Mojave or Great Basin Deserts and repository activities would affect a very small percentage of the available habitat in the region. Changes in the regional population of any species would be undetectable and no species would be threatened with extinction. The removal of vegetation from the small area required for Module 1 or 2 or the local loss of small numbers of individuals of some species due to site clearing and vehicle traffic would not affect regional biodiversity and ecosystem function. The loss of desert tortoise habitat and small numbers of tortoises under Module 1 or 2 would have no impact on recovery efforts for this threatened species.

Activities associated with other Federal, non-Federal, and private actions in the region should not add measurable impacts to the overall impact on biological resources. However, as stated in the Nevada Test Site EIS (DIRS 101811-DOE 1996, p. 6-16), cumulative impacts to the desert tortoises would occur throughout the region, although the intensity of the impacts would vary from location to location. The largest impact to the habitat probably would occur in the Las Vegas Valley region. The Clark County Desert Conservation Plan authorizes the taking of all tortoises on 445 square kilometers (110,000 acres) of non-Federal land in the County, and on 12 square kilometers (3,000 acres) disturbed by Nevada

Department of Transportation activities in Clark and adjacent counties. The plan also authorizes several recovery units designed to optimize the survival and recovery of this threatened species. Potential land disturbance activities at the Nevada Test Site under the expanded use alternative represent a small amount of available desert tortoise habitat and will not add measurably to the loss of this species (DIRS 101811-DOE 1996, p. 6-16). As discussed in Chapter 4, Section 4.1.4, repository construction activities would involve the loss of an amount of desert tortoise habitat that would be small in comparison to its range. Yucca Mountain is at the northern end of the range of this species. DOE anticipates that small numbers of tortoises would be killed inadvertently by vehicle traffic during the repository construction, operation and monitoring, and closure phases.

8.2.5 CULTURAL RESOURCES

The only identified actions that could result in cumulative cultural resource impact in the Yucca Mountain site vicinity are Inventory Module 1 or 2. The emplacement of either module would require small additional disturbances to land in areas already surveyed during site characterization activities (see Table 8-4). Because repository construction, operation and monitoring, and closure would be Federal actions, DOE would identify and evaluate cultural resources, as required by Section 106 of the National Historic Preservation Act, and would take appropriate measures to avoid or mitigate adverse impacts to such resources. As a consequence, archaeological information gathered from artifact retrieval during land disturbance would contribute additional cultural resources information to the regional data base for understanding past human occupation and use of the land. However, there would be a potential for illicit or incidental vandalism of archaeological or historic sites and artifacts as a result of increased activities in the repository area, which would be extended for Module 1 or 2 (see Table 8-3), and this could contribute to an overall loss of regional cultural resources information.

The Native American view of resource management and preservation is holistic in its definition of cultural resources, incorporating all elements of the natural and physical environment in an interrelated context (DIRS 102043-AIWS 1998, all). The Native American perspective on cultural resources is further discussed in Chapter 3, Section 3.1.6. Potential impacts resulting from the Proposed Action described in Chapter 4, Section 4.1.5, would also apply to Inventory Module 1 or 2.

8.2.6 SOCIOECONOMICS

8.2.6.1 Inventory Modules 1 and 2 Impacts

This section addresses potential socioeconomic impacts associated with Inventory Module 1 or 2 and concludes that impacts for Inventory Module 1 or 2 would be essential the same during construction phase as the Proposed Action, slightly greater during the development and emplacement phases than the Proposed Action, the same during the monitoring phase, and slightly greater than impacts for the Proposed Action during the closure phase. The impacts in all phases for Module 1 or 2 would be small, as are impacts estimated for the Proposed Action (see Chapter 4, Section 4.1.6). DOE analyzed both the higher-temperature operating mode and the lower-temperature operating mode. Table 8-16 summarizes the peak direct employment levels during all phases for the Proposed Action and for the Inventory Modules.

Construction

DOE expects the construction phase to last for 5 years. The construction phase for Inventory Module 1 or 2 would require approximately 1,800 workers in the peak year, the same as the Proposed Action (see Table 8-16). The impacts for Module 1 or 2 would therefore be the same as those for the Proposed Action.

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Table 8-16. Estimated peak direct employment level impacts from repository phases.[a,b]

Phase	Proposed Action		Inventory Module 1 or 2	
	Higher-temperature	Lower-temperature	Higher-temperature	Lower-temperature
Construction	1,800	1,800	1,800	1,800
Operation and Monitoring				
Development, emplacement	1,700	1,800 - 1,900	1,700	1,700 - 2,600
Monitoring[c]	120	40 - 120	140	130 - 140
Closure	960	960	970	1,100 - 1,200

a. Includes approximately 220 currently employed workers.
b. Numbers rounded to two significant places.
c. Excludes approximately 1,100 workers required for decontamination (monitoring period). Number of required workers is approximately the same for both operating modes for Inventory Module 1 or 2.

Operation and Monitoring

For the Proposed Action, DOE expects the repository development to last for 22 years and emplacement to last for 24 years. With Modules 1 or 2, development would last 36 years and emplacement 38 years. If a design with an aging facility were selected, emplacement activities would last 50 years for the Proposed Action or 51 years for Module 1 or 2. Monitoring activities occur concurrently and then extend beyond the emplacement period for up to 300 years. Employment levels for Module 1 or 2 during this phase could require approximately 700 more workers than the estimated worker requirement for the Proposed Action (see Table 8-16). Although the overall duration of the operation phase, including the development, emplacement, and monitoring activities, varies in length depending on the final scenario of the flexible design, the primary difference between Inventory Module 1 or 2 and the Proposed Action is the increased duration of development and emplacement activities (by 14 years).

The annualized impacts during development and emplacement activities for Inventory Module 1 or 2 would be similar to those for the Proposed Action, but these impacts would continue for an additional 14 years. As with the Proposed Action, direct and indirect increases in regional employment, population, Gross Regional Product, real disposal income, and government expenditures would be small, 3 percent or less of the baselines, for affected counties. No substantial socioeconomic impacts would be likely during the operations phase.

Closure

DOE expects the closure phase to last between 12 and 23 years. Although the required staffing level for Inventory Module 1 or 2 would be slightly greater, but similar in impact, to that of the Proposed Action, Inventory Module 1 or 2 would require more time. Closure would last up to 23 years for Inventory Module 1 or 2. However, as with the Proposed Action, because work force demands would be less than the peak year employment demands during the operations or construction phase, impacts to regional employment, population, Gross Regional Product, real disposal income, and government expenditures would be very small. No substantial impact would likely occur during the closure for Inventory Module 1 or 2.

8.2.6.2 Cumulative Impacts from Inventory Module 1 or 2 and Other Federal, Non-Federal, and Private Actions

Reasonably foreseeable future actions at the Nevada Test Site could affect the socioeconomic region of influence (Nye, Clark, and Lincoln Counties). Sections 8.1.1 and 8.1.2 discuss other activities in the region that could have a socioeconomic impact. However, most of these activities have either already occurred or would occur prior to peak employment associated with the proposed repository. Because of the minimal amount of overlap that would occur in the activities, the affected communities would have more time to assimilate any new residents that might relocate to the region. Thus, no substantial impacts would be likely to occur from these activities.

8.2.7 OCCUPATIONAL AND PUBLIC HEALTH AND SAFETY

This section discusses the short-term health and safety impacts to workers and to members of the public (radiological only) associated with construction, operation and monitoring, and closure activities at the Yucca Mountain site for Inventory Module 1 or 2 (Sections 8.2.7.1 through 8.2.7.3). Section 8.2.7.4 provides a summary of these impacts. Appendix F contains the approach and methods used to estimate the health and safety impacts and additional detailed results for Module 1 or 2 health and safety impacts to workers.

With one exception, no other Federal, non-Federal, or private actions were identified with spatially or temporally coincident short-term impacts in the region of influence that would result in cumulative health and safety impacts with those of the proposed Yucca Mountain Repository. Chapter 3 discusses the potential radiological doses from past weapons testing at the Nevada Test Site. While all of the current population was not present at the time of the testing, residents who were present during the time periods when weapons testing (in particular, atmospheric weapons testing from the 1950s to the early 1960s) occurred could have received as much as 5 rem to the thyroid gland from iodine-131 releases. Using a tissue-weighting factor of 0.03 as specified in International Commission on Radiological Protection Publication 26 (DIRS 101075-ICRP 1977, all), this would equate to an effective dose equivalent of about 150 millirem. Because of the length of time since atmospheric weapons testing ceased, essentially all of this dose has already occurred. This dose would apply only to those residents who lived in the region of influence during the time period of atmospheric weapons testing. DOE has not added this dose to the maximally exposed individual dose, but DOE has included this information so that long-term residents in the region of influence can evaluate their potential for impacts from past nuclear weapons testing. (The dose is included in the risk estimates in Table 8-60 for the summary of public health and safety.)

With the increased number of persons living and working in the region, the number of injuries and fatalities from nonrepository-related activities would increase. However, injury and mortality incidence should remain unchanged or decrease, assuming the continued enforcement of occupational and public health and safety regulations.

Regarding the health and safety impact analysis for Inventory Module 1 or 2, the radiological characteristics of the spent nuclear fuel and high-level radioactive waste would be the same as those for the Proposed Action; there just would be more material to emplace. As described in Appendix A, the radioactive inventory (and radiological properties) of the Greater-Than-Class-C waste and Special-Performance-Assessment-Required waste is much less than that for spent nuclear fuel and high-level radioactive waste. Therefore, the subsurface emplacement of the material in Inventory Module 2 would not greatly increase radiological impacts to workers over those estimated for Module 1. For the surface facility evaluation, the number of workers would be the same for Inventory Module 1 or 2 (DIRS 104508-CRWMS M&O 1999, Section 3.3, third paragraph). Therefore, DOE did not perform separate impact analyses for Modules 1 and 2.

The primary changes in the parameters that would affect the magnitude of the worker health and safety impacts between the Proposed Action and Inventory Module 1 or 2 would be the periods required to perform the work and the numbers of workers for the different phases. Appendix F, Table F-43 p. 2 contains a detailed breakdown of the estimates for the involved and noninvolved workforce for the repository phases for Inventory Module 1 or 2 in terms of full-time equivalent worker-years.

For the public, the principal changes in parameters that would affect the magnitude of the health impact estimates would be the length of the various phases and the rate at which air would be exhausted from the repository. The exhaust rate of the subsurface ventilation system would affect both the radon-222 concentrations to which subsurface workers would be exposed and the quantity of radon-222 released to

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the environment. Appendix G, Section G.2.3.1, discusses radon-222 concentrations in the subsurface environment and release rates to the environment from the various project phases.

8.2.7.1 Construction

This section presents estimates of health and safety impacts to repository workers and members of the public for the construction phase. The values are similar to those for the Proposed Action because the length of the construction phase would be the same and activities would be similar.

Industrial Hazards

Table 8-17 lists health and safety hazards to workers common to the workplace. They are based on the health and safety loss statistics listed in Appendix F, Tables F-4 and F-5. For Inventory Module 1 or 2 these impacts would be independent of the operating mode because the number of workers would be the same for both operating modes.

Table 8-17. Summary of industrial hazard health and safety impacts to facility workers during the construction phase.[a]

Worker group	Operating mode	
	Higher-temperature	Lower-temperature
	Proposed Action	
Involved worker		
Total recordable cases of injury and illness	340	340 - 370
Lost workday cases	160	160 - 180
Fatalities	0.16	0.16 - 0.18
Noninvolved worker		
Total recordable cases of injury and illness	55	55 - 61
Lost workday cases	27	27 - 30
Fatalities	0.048	0.048 - 0.054
All workers		
Total recordable cases of injury and illness	400	400 - 430
Lost workday cases	190	190 - 210
Fatalities	0.21	0.21 - 0.23
	Inventory Module 1 or 2	
Involved worker		
Total recordable cases of injury and illness	340	340 - 370
Lost workday cases	160	160 - 180
Fatalities	0.16	0.16 - 0.18
Noninvolved worker		
Total recordable cases of injury and illness	55	55 - 61
Lost workday cases	27	27 - 30
Fatalities	0.048	0.048 - 0.054
All workers		
Total recordable cases of injury and illness	400	400 - 430
Lost workday cases	190	190 - 210
Fatalities	0.21	0.21 - 0.23

a. Source: Appendix F, Table F-12.

Radiological Health Impacts

This analysis presents radiological health impacts in terms of doses and resultant latent cancer fatalities. Estimated doses were converted to estimates of latent cancer fatality using a dose-to-risk conversion factor of 0.0004 and 0.0005 latent cancer fatality per person-rem for workers and the public, respectively (see Appendix F, Section F.1.1.5).

Workers. Spent nuclear fuel and high-level radioactive waste would not be present during the construction phase. Potential radiological impacts to surface workers during this phase would be limited to those from releases of naturally occurring radon-222 and its decay products with the subsurface ventilation exhaust (these impacts are presented in Section 8.2, Table 8-10). Subsurface workers would incur exposure from radiation resulting from radionuclides in the walls of the drifts and from inhalation of radon-222 in the subsurface atmosphere. Surface worker exposure would be very small compared to those for subsurface workers. The radiological doses and health impacts for Inventory Module 1 or 2 are listed in Table 8-18. The Module 1 or 2 impacts would be independent of the operating mode because the subsurface workforce would not change.

Table 8-18. Summary of radiological health impacts to workers from all activities during construction phase.[a]

Worker group	Operating mode	
	Higher-temperature	Lower-temperature
	Proposed Action	
Involved worker		
Dose to maximally exposed worker (millirem)	1,300	1,300
Probability of latent cancer fatality	0.00052	0.00052
Collective dose (person-rem)	680	680
Number of latent cancer fatalities	0.27	0.27
Noninvolved worker		
Dose to maximally exposed worker (millirem)	330	330
Probability of latent cancer fatality	0.00013	0.00013
Collective dose (person-rem)	37	37
Number of latent cancer fatalities	0.015	0.015
All workers		
Collective dose (person-rem)	720	720
Number of latent cancer fatalities	0.29	0.29
	Inventory Module 1 or 2	
Involved worker		
Dose to maximally exposed worker (millirem)	1,300	1,300
Probability of latent cancer fatality	0.00052	0.00052
Collective dose (person-rem)	680	680
Number of latent cancer fatalities	0.27	0.27
Noninvolved worker		
Dose to maximally exposed worker (millirem)	330	330
Probability of latent cancer fatality	0.00013	0.00013
Collective dose (person-rem)	37	37
Number of latent cancer fatalities	0.015	0.015
All workers		
Collective dose (person-rem)	720	720
Number of latent cancer fatalities	0.29	0.29

a. Source: Appendix F, Table F-11.

Public. Potential radiological impacts to the public during the construction phase would be limited to those from the release of naturally occurring radon-222 with the exhaust from subsurface ventilation. Table 8-19 presents radiological health impacts for the public surrounding the proposed repository.

8.2.7.2 Operations

This section presents estimates of health and safety impacts to workers and members of the public during the operations period. The primary differences between Inventory Module 1 or 2 and the Proposed Action would be the longer durations for development and emplacement activities. Under Module 1 or 2,

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Table 8-19. Radiological health impacts to the public from the construction phase.[a]

Impact	Higher-temperature Total	Higher-temperature Maximum annual	Lower-temperature Total	Lower-temperature Annual
	Proposed Action			
Dose to public				
Offsite MEI[b] (millirem)	1.7	0.43	1.7 - 2	0.43 - 0.53
80-kilometer population (person-rem)	33	8.4	33 - 40	8.4 - 10
Offsite MEI probability of latent cancer fatality	8.5×10^{-7}	2.1×10^{-7}	8.5×10^{-7} - 0.000001	2.1×10^{-7} - 2.6×10^{-7}
80-kilometer population number of latent cancer fatalities	0.017	0.0042	0.017 - 0.02	0.0042 - 0.0052
	Inventory Module 1 or 2			
Dose to public				
Offsite MEI (millirem)	1.7	0.43	2	0.52 - 0.53
80-kilometer population (person-rem)	33	8.4	39 - 40	10
Offsite MEI probability of latent cancer fatality	8.5×10^{-7}	2.1×10^{-7}	9.9×10^{-7} - 0.000001	2.6×10^{-7} - 2.6×10^{-7}
80-kilometer population number of latent cancer fatalities	0.017	0.0042	0.019 - 0.02	0.0051 - 0.0052

a. Sources: Chapter 4, Table 4-23; Appendix G, Section G.2.
b. MEI = maximally exposed individual.

it would take DOE 14 more years to complete drift development (36 years total) than for the Proposed Action and 14 more years to complete emplacement (38 years total) than for the Proposed Action.

Industrial Hazards

Table 8-20 lists health and safety impacts to workers from industrial hazards common to the workplace. These impacts would be about 50 to 60 percent greater than those calculated for the Proposed Action.

Radiological Impacts

Workers. Table 8-21 lists radiological doses and health impacts to workers during the operations period for Inventory Module 1 or 2. Appendix F contains additional detail and presents the radiological impacts for surface workers, subsurface workers, and monitoring activities. Radiological impacts to workers for Module 1 or 2 would be about 50 to 60 percent greater than those for the Proposed Action.

Public. Potential radiological impacts to the public from the operations period would result from the release of naturally occurring radon-222 and its decay products with the subsurface exhaust ventilation air and from radioactive gases, principally krypton-85, that could be released from the Waste Handling Building during spent nuclear fuel handling operations.

Table 8-22 lists the total radiological doses and radiological health impacts to the public from releases to the atmosphere of krypton-85 and radon-222 during the operations period. Radon-222 and its decay products would be the dominant dose contributors (greater than 99 percent).

8.2.7.3 Monitoring

This section contains estimates of the health and safety impacts to workers and members of the public for the monitoring period. The length of this period would depend on the operating mode; however, the monitoring phase for Inventory Module 1 or 2 would generally be shorter than the corresponding monitoring phase for the Proposed Action as shown in Table 8-3.

Industrial Hazards

Table 8-23 lists health and safety impacts to workers from hazards common to the workplace. As discussed above, the duration of the monitoring period for the Inventory Modules is shorter than that for the Proposed Action; therefore, the industrial safety impacts would be less for the Inventory Modules than for the Proposed Action.

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Table 8-20. Summary of industrial hazard health and safety impacts to facility workers during operations period.

Worker group	Operating mode	
	Higher-temperature	Lower-temperature
	Proposed Action	
Involved worker		
Total recordable cases of injury and illness	1,200	1,200 - 1,700
Lost workday cases	590	620 - 840
Fatalities	0.9	0.91 - 1.4
Noninvolved worker		
Total recordable cases of injury and illness	300	310 - 470
Lost workday cases	150	150 - 230
Fatalities	0.31	0.31 - 0.45
All workers		
Total recordable cases of injury and illness	1,500	1,500 - 2,200
Lost workday cases	740	770 - 1,100
Fatalities	1.2	1.2 - 1.9
	Inventory Module 1 or 2	
Involved worker		
Total recordable cases of injury and illness	1,900	1,900 - 2,200
Lost workday cases	970	970 - 1,100
Fatalities	1.4	1.4 - 1.7
Noninvolved worker		
Total recordable cases of injury and illness	470	470 - 560
Lost workday cases	230	230 - 270
Fatalities	0.46	0.46 - 0.54
All workers		
Total recordable cases of injury and illness	2,400	2,400 - 2,800
Lost workday cases	1,200	1,200 - 1,400
Fatalities	1.9	1.9 - 2.2

a. Source: Appendix F, Tables F-22 and F-52.

Radiological Impacts

Workers. Table 8-24 lists radiological doses and health impacts from activities during the monitoring period. During this period the primary source of collective dose to the involved subsurface worker population would be the inhalation dose from radon-222 while the primary source of collective dose to the involved surface worker population would be direct exposure to the waste packages.

Public. Table 8-25 lists the radiological doses and health impacts to the public from activities during the monitoring period. The primary source of these impacts is the release of radon-222 via subsurface ventilation flow.

8.2.7.4 Closure

This section contains estimates of health and safety impacts to workers and members of the public for the closure phase.

Industrial Hazards

Table 8-26 lists health and safety impacts to workers from hazards common to the workplace. The impacts for Inventory Module 1 or 2 would be slightly greater than those for the Proposed Action.

Radiological Impacts

Workers. Table 8-27 lists radiological doses and health impacts to workers during the closure phase. Subsurface workers would be exposed to radon-222 from inhalation of air in the drifts, to external

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Table 8-21. Summary of radiological health impacts to workers from all activities during operations period.[a]

Worker group	Operating mode: Higher-temperature	Operating mode: Lower-temperature
	Proposed Action	
Involved worker		
Dose to maximally exposed worker (millirem)	15,000	15,000 - 30,000
Probability of latent cancer fatality	0.006	0.006 - 0.012
Collective dose (person-rem)	7,500	7,600 - 12,000
Number of latent cancer fatalities	3.0	3.0 - 4.8
Noninvolved worker		
Dose to maximally exposed worker (millirem)	1,500	1,500 - 1,800
Probability of latent cancer fatality	0.0006	0.0006 - 0.00072
Collective dose (person-rem)	150	160 - 170
Number of latent cancer fatalities	0.06	0.064 - 0.068
All workers		
Collective dose (person-rem)	7,700	7,800 - 12,000
Number of latent cancer fatalities	3.1	3.1 - 4.8
	Inventory Module 1 or 2	
Involved worker		
Dose to maximally exposed worker (millirem)	24,000	24,000 - 33,000
Probability of latent cancer fatality	0.0096	0.0096 - 0.013
Collective dose (person-rem)	12,000	12,000 - 15,000
Number of latent cancer fatalities	4.8	4.8 - 6
Noninvolved worker		
Dose to maximally exposed worker (millirem)	2,400	2,400
Probability of latent cancer fatality	0.00096	0.00096
Collective dose (person-rem)	180	180 - 190
Number of latent cancer fatalities	0.072	0.072 - 0.076
All workers		
Collective dose (person-rem)	12,000	12,000 - 15,000
Number of latent cancer fatalities	4.8	4.8 - 6

a. Source: Appendix F, Tables F-23 and F-53.

Table 8-22. Radiological health impacts to the public from the operations period.

Impact	Higher-temperature: Total	Higher-temperature: Maximum annual	Lower-temperature: Total	Lower-temperature: Annual
	Proposed Action			
Dose to public				
Offsite MEI[a] (millirem)	12	0.73	17 - 43	1 - 1.3
80-kilometer population (person-rem)	230	14	320 - 830	20 - 26
Offsite MEI probability of latent cancer fatality	0.000006	3.7×10^{-7}	8.3×10^{-6} - 0.000022	5.2×10^{-7} - 6.7×10^{-7}
80-kilometer population number of latent cancer fatalities	0.12	0.0071	0.16 - 0.42	0.01 - 0.013
	Inventory Module 1 or 2			
Dose to public				
Offsite MEI (millirem)	22	0.94	31 - 66	1.3 - 2.2
80-kilometer population (person-rem)	430	18	600 - 1,300	26 - 42
Offsite MEI probability of latent cancer fatality	0.000011	4.7×10^{-7}	0.000016 - 0.000033	6.7×10^{-7} - 1.1×10^{-6}
80-kilometer population number of latent cancer fatalities	0.22	0.0091	0.3 - 0.64	0.013 - 0.021

a. MEI = maximally exposed individual.

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Table 8-23. Summary of industrial hazard health and safety impacts to facility workers during monitoring period.[a]

Worker group	Operating mode	
	Higher-temperature	Lower-temperature
	Proposed Action	
Involved worker		
Total recordable cases of injury and illness	320	400 - 1,000
Lost workday cases	130	160 - 410
Fatalities	0.31	0.38 - 1
Noninvolved worker		
Total recordable cases of injury and illness	55	65 - 150
Lost workday cases	27	32 - 73
Fatalities	0.049	0.057 - 0.13
All workers		
Total recordable cases of injury and illness	380	470 - 1,200
Lost workday cases	160	190 - 480
Fatalities	0.36	0.44 - 1.1
	Inventory Module 1 or 2	
Involved worker		
Total recordable cases of injury and illness	290	450 - 1,100
Lost workday cases	120	180 - 440
Fatalities	0.28	0.43 - 1.1
Noninvolved worker		
Total recordable cases of injury and illness	51	74 - 160
Lost workday cases	25	36 - 78
Fatalities	0.045	0.065 - 0.14
All workers		
Total recordable cases of injury and illness	340	520 - 1,300
Lost workday cases	150	220 - 520
Fatalities	0.33	0.50 - 1.2

a. Source: Appendix F, Tables F-31 and F-59.

radiation from radionuclides in the rock in the drift walls, and to external radiation emanating from the waste packages.

Public. Potential radiation-related health impacts to the public from closure activities would result from releases of radon-222 in the subsurface ventilation flow. Section 8.2.2.1.2 describes radiation doses to the public for this phase. Table 8-28 lists radiological dose and health impacts for the closure phase. Radiological health impacts to the public for the inventory modules would be greater than those for the Proposed Action largely because of the longer time period for closure activities (see Table 8-3).

8.2.7.5 Summary

This section contains three summary tables:

- A summary of health impacts to workers from industrial hazards common to the workplace for all phases (Table 8-29)
- A summary of radiological doses and health impacts to workers for all phases (Table 8-30)
- A summary of radiological doses and health impacts to the public for all phases (Table 8-31)

Table 8-24. Summary of radiological health impacts to workers from all activities during monitoring period.[a]

Worker group	Operating mode: Higher-temperature	Operating mode: Lower-temperature
	Proposed Action	
Involved workers		
Dose to maximally exposed worker (millirem)	18,000	18,000
Probability of latent cancer fatality	0.0072	0.0072
Collective dose (person-rem)	1,100	1,500 - 4,300
Number of latent cancer fatalities	0.44	0.6 - 1.7
Noninvolved workers		
Dose to maximally exposed worker (millirem)	1,800	1,800
Probability of latent cancer fatality	0.00072	0.00072
Collective dose (person-rem)	36	46 - 140
Number of latent cancer fatalities	0.014	0.018 - 0.056
All workers		
Collective dose (person-rem)	1,100	1,500 - 4,400
Number of latent cancer fatalities	0.44	0.6 - 1.8
	Inventory Module 1 or 2	
Involved workers		
Dose to maximally exposed worker (millirem)	18,000	18,000
Probability of latent cancer fatality	0.0072	0.0072
Collective dose (person-rem)	990	1,700 - 4,500
Number of latent cancer fatalities	0.4	0.68 - 1.8
Noninvolved workers		
Dose to maximally exposed worker (millirem)	1,800	1,800
Probability of latent cancer fatality	0.00072	0.00072
Collective dose (person-rem)	31	56 - 150
Number of latent cancer fatalities	0.012	0.022 - 0.06
All workers		
Collective dose (person-rem)	1,000	1,800 - 4,700
Number of latent cancer fatalities	0.4	0.72 - 1.9

a. Source: Appendix F, Table F-32 and F-60.

Table 8-25. Radiological health impacts to the public from the monitoring period.

Impact	Higher-temperature: Total	Higher-temperature: Maximum annual	Lower-temperature: Total	Lower-temperature: Annual
	Proposed Action			
Dose to public				
Offsite MEI[a] (millirem)	29	0.41	30 - 62	0.59 - 0.89
80-kilometer population (person-rem)	600	8	1,500 - 3,500	11 - 17
Offsite MEI probability of latent cancer fatality	0.000015	2.1×10^{-7}	0.000015 - 0.000031	3×10^{-7} - 4.4×10^{-7}
80-kilometer population number of latent cancer fatalities	0.3	0.004	0.75 - 1.7	0.0057 - 0.0085
	Inventory Module 1 or 2			
Dose to public				
Offsite MEI (millirem)	39	0.62	20 - 100	0.29 - 1.4
80-kilometer population (person-rem)	740	12	2,200 - 5,400	5.6 - 28
Offsite MEI probability of latent cancer fatality	0.000019	3.1×10^{-7}	0.00001 - 0.00005	1.5×10^{-7} - 7.2×10^{-7}
80-kilometer population number of latent cancer fatalities	0.37	0.006	1.1 - 2.7	0.0028 - 0.014

a. MEI = maximally exposed individual.

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Table 8-26. Summary of industrial hazard health and safety impacts to facility workers during closure phase.[a]

Worker group	Operating mode	
	Higher-temperature	Lower-temperature
	Proposed Action	
Involved worker		
Total recordable cases of injury and illness	320	340 - 420
Lost workday cases	150	160 - 200
Fatalities	0.15	0.16 - 0.2
Noninvolved worker		
Total recordable cases of injury and illness	51	53 - 62
Lost workday cases	25	26 - 30
Fatalities	0.045	0.047 - 0.054
All workers		
Total recordable cases of injury and illness	370	390 - 480
Lost workday cases	180	190 - 230
Fatalities	0.2	0.21 - 0.25
	Inventory Module 1 or 2	
Involved worker		
Total recordable cases of injury and illness	350	400 - 600
Lost workday cases	170	190 - 280
Fatalities	0.17	0.19 - 0.28
Noninvolved worker		
Total recordable cases of injury and illness	54	59 - 82
Lost workday cases	26	29 - 40
Fatalities	0.048	0.052 - 0.072
All workers		
Total recordable cases of injury and illness	400	460 - 680
Lost workday cases	200	220 - 320
Fatalities	0.22	0.24 - 0.35

a. Source: Appendix F, Tables F-38 and F-66.

Industrial Hazards to Workers

Table 8-29 summarizes health and safety impacts to workers from industrial hazards common to the workplace for all phases. The calculated health impacts from industrial hazards common to the workplace would be in the range of 2 to 3 fatalities for Inventory Module 1 or 2. Most of the impacts would come from the operations period. Industrial safety impacts for Module 1 or 2 are about 30 to 40 percent greater than those for the Proposed Action.

Radiological Health

Workers. Table 8-30 summarizes radiological doses and health impacts to workers for the Proposed Action and Inventory Module 1 or 2. It lists these impacts as the likelihood of a latent cancer fatality for the maximally exposed individual worker over a 50-year working career, and as the number of latent cancer fatalities that could occur in the population. The calculated values for latent cancer fatalities for repository workers during the construction, operation and monitoring, and closure phases for Module 1 or 2 are in the range of 6 to 8 fatalities for Module 1 or 2. These are higher than those for the Proposed Action (4 to 7 fatalities) and would be about double those from normal workplace industrial hazards (see Table 8-29).

Most of the total worker radiation dose would be from the receipt and handling of spent nuclear fuel during the operation period. Radiation exposure from inhalation of radon-222 and its decay products by exposure to radiation emanating from the subsurface would also be contributors to the total dose. No other activities in the area were identified that could cause cumulative impacts to repository workers.

Table 8-27. Summary of radiological health impacts to workers from all activities during closure phase.[a]

Worker group	Operating mode: Higher-temperature	Operating mode: Lower-temperature
	Proposed Action	
Involved worker		
Total recordable cases of injury and illness	320	340 - 420
Lost workday cases	150	160 - 200
Fatalities	0.15	0.16 - 0.2
Noninvolved worker		
Total recordable cases of injury and illness	51	53 - 62
Lost workday cases	25	26 - 30
Fatalities	0.045	0.047 - 0.054
All workers		
Total recordable cases of injury and illness	370	390 - 480
Lost workday cases	180	190 - 230
Fatalities	0.2	0.21 - 0.25
	Inventory Module 1 or 2	
Involved worker		
Total recordable cases of injury and illness	350	400 - 600
Lost workday cases	170	190 - 280
Fatalities	0.17	0.19 - 0.28
Noninvolved worker		
Total recordable cases of injury and illness	54	59 - 82
Lost workday cases	26	29 - 40
Fatalities	0.048	0.052 - 0.072
All workers		
Total recordable cases of injury and illness	400	460 - 680
Lost workday cases	200	220 - 320
Fatalities	0.22	0.24 - 0.35

a. Source: Appendix F, Tables F-39 and F-67.

Table 8-28. Radiological health impacts to the public from the closure phase.

Impact	Higher-temperature: Total	Higher-temperature: Maximum annual	Lower-temperature: Total	Lower-temperature: Annual
	Proposed Action			
Dose to public				
Offsite MEI[a] (millirem)	3	0.39	4.3 - 9.4	0.55 - 0.85
80-kilometer population (person-rem)	57	7.4	83 - 180	10 - 16
Offsite MEI probability of latent cancer fatality	1.5×10^{-6}	1.9×10^{-7}	2.2×10^{-6} - 4.7×10^{-6}	2.7×10^{-7} - 4.2×10^{-7}
80-kilometer population number of latent cancer fatalities	0.028	0.0037	0.041 - 0.09	0.0052 - 0.0081
	Inventory Module 1 or 2			
Dose to public				
Offsite MEI (millirem)	4.9	0.57	8.5 - 19	0.83 - 1.4
80-kilometer population (person-rem)	95	11	160 - 360	16 - 26
Offsite MEI probability of latent cancer fatality	2.5×10^{-6}	2.9×10^{-7}	4.2 × 10-6 - 9.5×10^{-6}	4.2×10^{-7} - 6.9×10^{-7}
80-kilometer population number of latent cancer fatalities	0.047	0.0055	0.081 - 0.18	0.008 - 0.013

a. MEI = maximally exposed individual.

Public. Table 8-31 summarizes radiological doses and health impacts to the public during all phases for the Proposed Action and Inventory Module 1 or 2. The radiological doses and health impacts would result from exposure of the public to naturally occurring radon-222 and decay products released from the subsurface facilities in ventilation exhaust air. The calculated likelihood for Module 1 or 2 that the maximally exposed individual would experience a latent cancer fatality is less than 0.00005. The

Table 8-29. Summary of industrial hazard health and safety impacts to facility workers during all phases.[a]

Worker group	Operating mode: Higher-temperature	Operating mode: Lower-temperature[b]
	Proposed Action	
Involved worker		
Total recordable cases of injury and illness	2,200	2,500 - 3,300
Lost workday cases	1,000	1,200 - 1,500
Fatalities	1.5	1.8 - 2.6
Noninvolved worker		
Total recordable cases of injury and illness	470	500 - 720
Lost workday cases	230	250 - 350
Fatalities	0.45	0.48 - 0.68
All workers		
Total recordable cases of injury and illness	2,700	3,000 - 4,000
Lost workday cases	1,200	1,500 - 1,900
Fatalities	2	2.3 - 3.3
	Inventory Module 1 or 2	
Involved worker		
Total recordable cases of injury and illness	2,900	3,400 - 4,000
Lost workday cases	1,400	1,600 - 1,900
Fatalities	2.1	2.4 - 3.1
Noninvolved worker		
Total recordable cases of injury and illness	640	690 - 830
Lost workday cases	310	340 - 410
Fatalities	0.61	0.65 - 0.78
All workers		
Total recordable cases of injury and illness	3,500	4,100 - 4,800
Lost workday cases	1,700	1,900 - 2,300
Fatalities	2.7	3.1 - 3.9

a. Source: Appendix F, Tables F-40 and F-68.
b. These ranges might differ from simple addition of the minimum and maximum values listed for the constituent phases because the values might not correspond between different phases. For example, a scenario that maximizes impacts during construction could result in minimal impacts during operations.

estimated increase in the number of latent cancer fatalities is less than 2 for the exposed population within about 80 kilometers (50 miles) over the period of more than 100 years of repository activities.

For purposes of comparison, the number of latent cancer fatalities calculated from the public for the Yucca Mountain construction, operation and monitoring, and closure phases for Inventory Module 1 or 2 would be less than 0.75. Statistics published by the Centers for Disease Control indicate that during 1998, 24 percent of all deaths in the State of Nevada were attributable to cancer of some type and cause (adapted from DIRS 153066-Murphy 2000, p. 83). Assuming this rate would remain unchanged for the estimated population in 2035 of about 76,000 within 80 kilometers (50 miles) of the Yucca Mountain site, about 18,000 members of this population would be likely to die from cancer-related causes.

As discussed in Section 8.2.2.2.2, the current operations at the Nevada Test Site resulted in a dose to the maximally exposed individual in 1999 of 0.12 millirem. During that same year, the population dose from Nevada Test Site activities was 0.38 person-rem. Conservatively adding the doses from repository activities to Nevada Test Site activities would result in a dose of 2.3 millirem to the maximally exposed individual and 42 person-rem to the population.

As discussed in the introduction to Section 8.2.7, potential radiological doses from past weapons testing at the Nevada Test Site could result in additional impacts to those residents who were present during that

Table 8-30. Summary of radiological health impacts to workers from all activities during all phases.[a]

Worker group	Operating mode: Higher-temperature	Operating mode: Lower-temperature[b]
	Proposed Action	
Involved worker		
Dose to maximally exposed worker (millirem)	18,000	18,000 - 30,000
Probability of latent cancer fatality	0.0072	0.0072 - 0.012
Collective dose (person-rem)	9,800	11,000 - 17,000
Number of latent cancer fatalities	3.9	4.4 - 6.8
Noninvolved worker		
Dose to maximally exposed worker (millirem)	1,800	1,800
Probability of latent cancer fatality	0.00072	0.00072
Collective dose (person-rem)	230	280 - 360
Number of latent cancer fatalities	0.092	0.11 - 0.14
All workers		
Collective dose (person-rem)	10,000	11,000 - 17,000
Number of latent cancer fatalities	4	4.4 - 6.8
	Inventory Module 1 or 2	
Involved worker		
Dose to maximally exposed worker (millirem)	24,000	24,000 - 33,000
Probability of latent cancer fatality	0.0096	0.0096 - 0.013
Collective dose (person-rem)	14,000	16,000 - 20,000
Number of latent cancer fatalities	5.6	6.4 - 8
Noninvolved worker		
Dose to maximally exposed worker (millirem)	2,400	2,400
Probability of latent cancer fatality	0.00096	0.00096
Collective dose (person-rem)	270	330 - 410
Number of latent cancer fatalities	0.11	0.13 - 0.16
All workers		
Collective dose (person-rem)	14,000	16,000 - 20,000
Number of latent cancer fatalities	5.6	6.4 - 8

a. Source: Appendix F, Tables F-41 and F-69.
b. These ranges might differ from simple addition of the minimum and maximum values listed for the constituent phases because the values might not correspond between different phases. For example, a scenario that maximizes impacts during construction could result in minimal impacts during operations.

Table 8-31. Summary of radiological health impacts to the public from all project phases.

Impact	Higher-temperature: Total	Higher-temperature: Maximum annual	Lower-temperature[a]: Total	Lower-temperature[a]: Annual
		Proposed Action		
Dose to public				
Offsite MEI[b] (millirem)	31	0.73	44 - 62	1 - 1.3
80-kilometer population (person-rem)	930	14	1,900 - 3,900	20 - 26
Offsite MEI probability of latent cancer fatality	0.000016	3.7×10^{-7}	0.000022 - 0.000031	5.2×10^{-7} - 6.7×10^{-7}
80-kilometer population number of latent cancer fatalities	0.46	0.0071	0.97 - 2	0.010 - 0.013
		Inventory Module 1 or 2		
Dose to public				
Offsite MEI (millirem)	51	0.94	60 - 110	1.3 - 2.2
80-kilometer population (person-rem)	1,300		3,100 - 6,200	5.6 - 42
Offsite MEI probability of latent cancer fatality	0.000026	4.7×10^{-7}	0.00003 - 0.000057	6.7×10^{-7} - 1.1×10^{-6}
80-kilometer population number of latent cancer fatalities	0.65	0.0091	1.5 - 3.1	0.0028 - 0.021

a. These ranges might differ from simple addition of the minimum and maximum values listed for the constituent phases because the values might not correspond between different phases. For example, a scenario that maximizes impacts during construction could result in minimal impacts during operations.
b. MEI = maximally exposed individual.

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timeframe. If the maximally exposed individual is assumed to have also been present during the entire time period in which weapons testing occurred, the maximally exposed individual dose listed in Table 8-31 could be increased by as much as 150 millirem. (These doses have been included in Table 8-60.)

8.2.8 ACCIDENTS

Disposal in the proposed repository of the additional spent nuclear fuel and high-level radioactive waste along with the Greater-Than-Class-C waste and Special-Performance-Assessment-Required waste in Inventory Module 1 or 2 would result in a very small increase in the estimated risk from accidents described in Chapter 4, Section 4.1.8, for the Proposed Action. The potential hazards and postulated accident scenarios identified and evaluated in Chapter 4, Section 4.1.8, would be the same as those for Module 1 or 2 because there would be no change to the basic repository design or operation. The time required for receipt, packaging, and emplacement of the additional waste would extend from 24 to 38 years, but the probability of an accident scenario (likelihood per year) would be essentially unaffected. The accident scenario consequences evaluated for the Proposed Action would bound those that could occur for Inventory Module 1 or 2 because the spent nuclear fuel and high-level radioactive waste, except the Greater-Than-Class-C waste and the Special-Performance-Assessment-Required waste, would be the same. DOE has not determined the final disposition method for Greater-Than-Class-C and Special-Performance-Assessment-Required waste but, based on the characteristics and expected packaging of these wastes (type and quantity of radionuclides; see Appendix A), the accident scenario consequences calculated in Chapter 4, Section 4.1.8 for spent nuclear fuel and high-level radioactive waste would be bounding. Therefore, substantial cumulative accident impacts would be unlikely for Inventory Module 1 or 2.

The analysis of potential external events in Appendix H considered the potential effects on the Yucca Mountain Repository if there was a decision in the future to resume nuclear weapons testing or from a possible vehicle launch or recovery accident at the proposed VentureStar®/Kistler project. An earlier environmental assessment (DIRS 100136-DOE 1986, all) states that DOE could temporarily suspend underground repository activities during a nuclear weapons test to ensure worker safety. The Department has not decided that such a suspension of work activities at the repository would be necessary at the present time; however, as it finalized the design of the proposed repository, the Department could find it necessary to enact worker safety requirements at the repository site if there was a resumption of nuclear weapons testing. As discussed in Section 8.1.2.2, the Kistler aerospace activity is currently on hold.

In addition, the analysis identified no other Federal, non-Federal, or private action that could affect either the occurrence probability or consequences of the accident scenarios evaluated for the Proposed Action or Inventory Modules.

8.2.9 NOISE

The emplacement of Inventory Module 1 or 2 would have noise levels associated with the construction and operation of the repository similar to those for the Proposed Action. An increase in potential noise impacts from Module 1 or 2 would result only from the increased number of shipments to the site. The expected rate of receipt would be about the same as that for the Proposed Action; therefore, the impact would be an extended period (approximately 14 years) that shipping would continue beyond the Proposed Action.

DOE does not expect other Federal, non-Federal, or private actions in the region to add measurable noise impacts to those of the Proposed Action or Inventory Module 1 or 2 because the other activities are some distance from the proposed repository, and it is unlikely that overall increased noise would result.

8.2.10 AESTHETICS

There would be no impacts for Inventory Module 1 or 2 beyond those described in Chapter 4, Section 4.1.10, because the profile of the repository facility would not be different as a result of implementation of Modules 1 or 2. One action that could add to cumulative aesthetics impacts of the region would be the construction and operation of a proposed wind farm (DIRS 154545-DOE 2001, all) on the Nevada Test Site. The locations being considered for the proposed wind farm are located within the areas of Pahute Mesa and the Shoshone Mountains. The areas under consideration are higher in elevation than the surrounding environs. With the addition of the wind turbine to maximum heights of approximately 430 feet above-ground surface these wind turbines may be visible from the west (especially from mountain ranges west of the Nevada Test Site).

8.2.11 UTILITIES, ENERGY, MATERIALS, AND SITE SERVICES

This section discusses potential impacts to utilities, energy, materials, and site services from the construction, operation and monitoring, and closure of the repository for Inventory Module 1 or 2. The scope of the analysis includes electricity use, fossil-fuel and oil and lubricant consumption, and consumption of construction materials. Chapter 4, Section 4.1.11, evaluates special services such as emergency medical support, fire protection, and security and law enforcement, which would not change for Inventory Module 1 or 2. The material in this section parallels Section 4.1.11, which addresses impacts from the Proposed Action. DOE has considered the other actions described in Section 8.1 to evaluate the potential for cumulative impacts on utilities, energy, materials, and site services. Most of the actions have limited information on their potential cumulative impacts, or the available information indicates that there could be no cumulative impacts. However, one action that would potentially have a cumulative impact is the Alternative Energy Generation Facility (Wind Farm) on the Nevada Test Site, which would increase electrical generating capacity for the region by approximately 600 megawatts, which represents less than 15 percent of the peak power (4,300 megawatts) distributed by Nevada Power in 2000, as described in Chapter 3, Section 3.1.11.2.

To determine the potential impacts of Inventory Module 1 or 2, DOE evaluated the projected uses of electricity, fuel, oils and lubricants and construction materials for each repository phase and compared them to those for the Proposed Action. The following paragraphs describe these evaluations.

Construction

As in the Proposed Action, the major impact during the construction phase for Inventory Module 1 or 2 would be the estimated demand for electric power. The peak demand for electricity for the Proposed Action would be 25 megawatts during construction (Table 8-32). During the construction required for Module 1 or 2, the peak demand for electricity would be about the same (25 megawatts). The tunnel boring machines would account for more than half of the demand for electricity during the 5-year construction phase, but power would also be required to operate ventilation equipment and to support the construction of surface facilities. As for the Proposed Action, the existing electric transmission and distribution system at the Nevada Test Site could not support this increased demand. DOE is evaluating modifications to the site electrical system, as discussed in Chapter 4, Section 4.1.11.

The use of electricity for the higher-temperature operating mode for Inventory Module 1 or 2 would be about 150,000 megawatt-hours during the construction phase, which is about the same as for the Proposed Action (see Table 8-33). For the lower-temperature operating mode the electricity usage ranges from 190,000 to 210,000 megawatt-hours, which is the same as for the Proposed Action. The similarity in numbers between the Proposed Action and the Inventory Modules is due to the similar length of time for construction activities.

Table 8-32. Peak electric power demand (megawatts).

Phase	Operating mode: Higher-temperature	Operating mode: Lower-temperature
Proposed Action		
Construction	25	25
Operation and monitoring		
Operation	47	40 - 54
Monitoring	8	7.8 - 15
Closure	10	10 - 18
Maximum	47	40 - 54
Inventory Module 1 or 2		
Construction	25	25
Operation and monitoring		
Operation	53	44 - 54
Monitoring	11	11 - 15
Closure	14	10 - 18
Maximum	53	44 - 54

Table 8-33. Electricity use (1,000 megawatt-hours).

Phase	Operating mode: Higher-temperature	Operating mode: Lower-temperature
Proposed Action		
Construction	150	190 - 210
Operation and monitoring		
Operation	5,200	5,300 - 9,200
Monitoring	4,800	9,700 - 29,000
Closure	720	790 - 1,300
Totals	***11,000***	***16,000 - 36,000***
Inventory Module 1 or 2		
Construction	150	190 - 200
Operation and monitoring		
Operation	8,200	7,700 - 9,700
Monitoring	6,000	11,000 - 39,000
Closure	1,100	1,300 - 1,600
Totals	***15,000***	***21,000 - 50,000***

The use of liquid fossil fuel during the construction phase would include diesel fuel and fuel oil. The estimated liquid fuel use would be 5.5 to 6 million liters (1.5 to 1.6 million gallons) which would be about the same as for the Proposed Action (see Table 8-34). About 2.6 to 3.5 million liters of oils (primarily hydraulic oil) and lubricants would also be used to support construction as shown in Table 8-35. The usage rate should be well within the regional supply capacity and, therefore, would not result in substantial impacts.

The primary materials needed to support construction would be concrete, steel, and copper. Concrete would be used for liners in the main drifts and ventilation shafts. Concrete also would be used in the construction of the surface facilities. The quantity of concrete required for the surface facilities and initial emplacement drift construction would be about 420,000 to 500,000 cubic meters (550,000 to 650,000 cubic yards). Cement (see Table 8-36) would come from regional suppliers. Sand and gravel needs would be met from materials excavated from the repository or hauled to the repository by local/ regional suppliers. As much as 120,000 metric tons (132,000 tons) of steel for a variety of uses including rebar, piping, vent ducts, and track, and 230 metric tons (250 tons) of copper for electrical cable also would be required. These quantities would not be likely to affect the regional supply capacity.

Table 8-34. Fossil-fuel use (million liters).

Phase	Operating mode	
	Higher-temperature	Lower-temperature
Proposed Action		
Construction	5.5	5.5 - 6.0
Operation and monitoring		
Operation	360	360 - 500
Monitoring	2.3	2.6 - 13
Closure	5.2	5.1 - 6.6
Totals	***370***	***380 - 510***
Inventory Module 1 or 2		
Construction	5.4	5.5 - 6.1
Operation and monitoring		
Operation	550	550 - 600
Monitoring	2.1	7 - 22
Closure	7.4	6.1 - 6.9
Totals	***560***	***570 - 620***

Table 8-35. Oils and lubricants (million liters).

Phase	Operating mode	
	Higher-temperature	Lower-temperature
Proposed Action		
Construction	2.6	3.1 - 3.5
Operation and monitoring		
Operation	8.5	9.8 - 18
Monitoring	9	13 - 53
Closure	1.7	1.8 - 3
Totals	***22***	***33 - 71***
Inventory Module 1 or 2		
Construction	2.6	3.1 - 3.5
Operation and monitoring		
Operation	13	16 - 27
Monitoring	9.9	23 - 110
Closure	3.8	2.9 - 3.2
Totals	***30***	***56 - 140***

Table 8-36. Cement use (1,000 metric tons).

Phase	Operating mode	
	Higher-temperature	Lower-temperature
Proposed Action		
Construction	160	190
Operation and monitoring		
Operation	100	150 - 340
Monitoring	0	0
Closure	1.2	1.2 - 1.9
Totals	***250***	***310 - 530***
Inventory Module 1 or 2		
Construction	160	160 - 190
Operation and monitoring		
Operation	260	290 - 890
Monitoring	0	0
Closure	1.9	1.9 - 2.0
Totals	***420***	***480 - 1,100***

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Operation and Monitoring

The event that would indicate the start of the operation and monitoring phase would be the beginning of emplacement of spent nuclear fuel and high-level radioactive waste. During this phase the construction of emplacement drifts would continue in parallel with emplacement activities at about the same rate as during the construction phase. As a result, the peak electric power demand would increase to between about 44 and 54 megawatts. The maximum value of 54 megawatts would be about the same as that for the Proposed Action. As was the case for the Proposed Action, DOE would have to upgrade or revise the transmission and distribution system on the Nevada Test Site to meet this demand. However, the upgrade or revision for the Proposed Action would accommodate the similar increase for Inventory Module 1 or 2.

The demand for electricity for Inventory Module 1 or 2 would be well within the regional capacity for power generation. Nevada Power Company, for example, plans to maintain a reserve capacity of about 12 percent. For the beginning of the operation and monitoring phase in 2010, Nevada Power projects a net peak load of about 6,000 megawatts and plans a reserve of about 710 megawatts (DIRS 103413-NPC 1997, Figure 4, p. 9). The repository peak demand of 54 megawatts would be less than 1 percent of the Nevada Power Company planned capacity and about 8 percent of planned reserves. The repository would not affect the regional availability of electric power to any extent.

Fossil-fuel use during the operation and monitoring phase would be for onsite vehicles and for heating. It should range between 360 and 500 million liters (100 and 130 million gallons) during repository operations. The corresponding use of oils and lubricants would be between 23 and 130 million liters (6 and 34 million gallons). The annual usage rates for fuels would be highest during the first half of the operation and monitoring phase (emplacement and continued construction of drifts) and would decrease substantially during the monitoring period (see Table 8-34). The projected annual usage rates of liquid petroleum products would be higher than those for the Proposed Action but would still be within the regional supply capacity.

Additional construction materials would be required to support the continued construction of subsurface facilities for Inventory Module 1 or 2. About 660,000 cubic meters (860,000 cubic yards) of concrete would be required for the flexible design, higher-temperature repository operating mode, and 730,000 to 2,300,000 cubic meters (950,000 to 3,000,000 cubic yards) would be required for the lower-temperature repository operating mode (see Table 8-37). Corresponding amounts of cement that would be obtained regionally are shown in Table 8-36.

Table 8-37. Concrete use (1,000 cubic meters).

Phase	Operating mode: Higher-temperature	Operating mode: Lower-temperature
Proposed Action		
Construction	420	490 - 500
Operation and monitoring		
Operation	240	350 - 880
Monitoring	0	0
Closure	3	3 - 5
Totals	***670***	***850 - 1,400***
Inventory Module 1 or 2		
Construction	420	430 - 490
Operation and monitoring		
Operation	660	730 - 2,300
Monitoring	0	0
Closure	5	4 - 5
Totals	***1,100***	***1,200 - 2,800***

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The requirement for steel would be between 120,000 and 360,000 metric tons (130,000 and 390,000 tons), and for copper it would be about 200 and 1,100 metric tons (220 and 1,200 tons) (see Tables 8-38 and 8-39). These quantities, while above the Proposed Action, would be unlikely to affect the regional supply capacity because the annual usage rate would be only slightly higher than that for the Proposed Action.

Table 8-38. Steel use (1,000 metric tons).

Phase	Operating mode	
	Higher-temperature	Lower-temperature
Proposed Action		
Construction	100	120
Operation and monitoring		
Operation	62	150 - 180
Monitoring	0	0
Closure	0.03	0.04
Totals	***160***	***270 - 300***
Inventory Module 1 or 2		
Construction	100	100 - 120
Operation and monitoring		
Operation	120	190 - 360
Monitoring	0	0
Closure	0.04	0.04 - 0.07
Totals	***230***	***290 - 480***

Table 8-39. Copper use (1,000 metric tons).

Phase	Operating mode	
	Higher-temperature	Lower-temperature
Proposed Action		
Construction	0.20	0.23
Operation and monitoring		
Operation	0.08	0.24 - 0.6
Monitoring	0	0
Closure	0	0
Totals	***0.30***	***0.50 - 0.86***
Inventory Module 1 or 2		
Construction	0.20	0.16 - 0.23
Operation and monitoring		
Operation	0.20	0.3 - 1.1
Monitoring	0	0
Closure	0	0
Totals	***0.4***	***0.46 - 1.3***

Closure

The peak electric power required during the closure phase for Inventory Module 1 or 2 would be only slightly higher than that for the Proposed Action and would be less than 20 megawatts for all operating modes. This would be much less than the peak levels predicted for the earlier phases, so impacts would be small.

Fossil-fuel use would be between 6.1 million and 7.4 million liters (1.6 million and 2.0 million gallons). A small amount of concrete and steel would be used for closure. An estimated maximum of 5,000 cubic meters (6,500 cubic yards) of concrete would be required for any operating mode. Similarly, an estimated maximum 70 metric tons (77 tons) of steel would be required for closure. The fossil-fuel and material quantities required for closure would not be large and would not result in substantial impacts.

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8.2.12 MANAGEMENT OF REPOSITORY-GENERATED WASTE AND HAZARDOUS MATERIALS

8.2.12.1 Inventory Module 1 or 2 Impacts

Activities for the emplacement of Inventory Module 1 or 2 would generate waste totals beyond the quantities estimated for the Proposed Action (see Chapter 4, Section 4.1.12). The generated waste types and the treatment and disposal of each waste type would be the same as those described for the Proposed Action. The quantities of generated waste are primarily affected by the increase in the amount of spent nuclear fuel and waste emplaced and the subsequent longer operations and monitoring and closure phases. (Table 8-3 lists the difference in time sequences.) Table 4-40 presents the waste types and quantities generated from activities during the construction phase. This table applies to both the Proposed Action and the Inventory Modules because the timeframe and actions are the same during this phase. Table 8-40 lists the waste quantities generated for Inventory Modules 1 and 2 for the operation and monitoring phase. Table 8-41 lists the waste quantities generated for Inventory Modules 1 and 2 for the closure phase.

Table 8-40. Estimated operation and monitoring phase waste quantities.[a]

Waste type	Operating mode	
	Higher-temperature	Lower-temperature
	Inventory Module 1	
Low-level radioactive (cubic meters)a	110,000	110,000 - 230,000
Hazardous (cubic meters)	10,000	9,200 - 16,000
	Inventory Module 2	
Low-level radioactive (cubic meters)	130,000	130,000 - 270,000
Hazardous (cubic meters)	12,000	11,000 - 20,000
	Inventory Module 1 or 2	
Sanitary and industrial solid (cubic meters)	110,000	120,000 - 170,000
Sanitary sewage[b] (million liters)	2,500	3,000 - 3,900
Industrial wastewater (million liters)	1,400	1,400 - 2,200

a. To convert cubic meters to cubic feet, multiply by 35.314.
b. To convert liters to gallons, multiply by 0.26418.

Table 8-41. Estimated closure phase waste quantities.[a]

Waste type	Inventory Module 1 or 2	
	Higher-temperature	Lower-temperature
Low-level radioactive (cubic meters)[b]	3,500	3,200 - 7,100
Hazardous (cubic meters)	1,200	1,100 - 1,800
Sanitary and industrial solid (cubic meters)	10,000	14,000 - 18,000
Sanitary sewage (million liters)[c]	180	240 - 410
Industrial wastewater (million liters)	84	110 - 160
Demolition debris (cubic meters)	220,000	220,000 - 440,000

a. To convert cubic meters to cubic feet, multiply by 35.314.
b. Module 1 is 7,000 cubic meters.
c. To convert liters to gallons, multiply by 0.26418.

Sanitary and industrial solid waste, sanitary sewage, and industrial wastewater would be disposed of in facilities at the repository site. These facilities would be designed to accommodate the additional waste from Inventory Module 1 or 2. However, DOE could use existing Nevada Test Site landfills to dispose of nonrecyclable construction and demolition debris and sanitary and industrial solid waste. If Nevada Test Site landfills were used, about 360,000 cubic meters (13 million cubic feet) for the higher-temperature operating mode and 640,000 cubic meters (23 million cubic feet) under the lower-temperature operating mode would be disposed of from construction through closure. Disposal of the Proposed Action waste quantities would require the Nevada Test Site landfills to operate past their projected operating lives and to expand as needed (Chapter 4, Section 4.1.12.2). Disposal of the larger waste quantities under Inventory Module 1 or 2 would require the availability of additional disposal capacity in future landfill expansions.

Impacts from the treatment and disposal of hazardous waste off the site would be the same for the Proposed Action and Inventory Module 1 or 2. At present, commercial facilities are available for hazardous waste treatment and disposal, and DOE expects similar facilities to be available until the closure of the repository. The National Capacity Assessment Report (DIRS 103245-EPA 1996, pp. 32, 33, 36, 46, 47, and 50) indicates that the estimated 20-year (1993 to 2013) available capacity for incineration of solids and liquids at permitted treatment facilities in the western states is about 7 times more than the demand for these services. Moreover, the report indicates that the estimated landfill capacity for hazardous waste disposal is about 50 times the demand. Given the current outlook for the capacity versus demand for hazardous waste treatment and disposal, the treatment and disposal of repository-generated hazardous waste would not present a large cumulative impact.

The Nevada Test Site has an estimated total disposal capacity of 3.7 million cubic meters (130 million cubic feet). The DOE analysis of demand for low-level radioactive waste disposal at the Nevada Test Site through 2070 projects a need for about 1.1 million cubic meters (39 million cubic feet or 30 percent) of the total disposal capacity (DIRS 155856-DOE 2000, Table 4-1). The reserve capacity at the Nevada Test Site is about 2.6 million cubic meters (92 million cubic feet). The disposal of repository-generated waste would require about 5 percent of the reserve capacity for the higher-temperature operating mode and about 5 percent to 9 percent for the lower-temperature operating mode.

Even under the Final Waste Management Programmatic Environmental Impact Statement's (DIRS 101816-DOE 1997, pp. 7-23 and I-39) regional disposal concept, the disposal of repository-generated low-level radioactive waste under the Proposed Action and Inventory Module 1 or 2, cumulatively with other DOE waste generators, would use less than 20 percent of the Nevada Test Site's reserve disposal capacity.

The emplacement of Inventory Module 1 or 2 would require the same types and annual quantities of hazardous materials as the Proposed Action, as described in Chapter 4, Section 4.1.12.3. These materials would be used for the additional years associated with the emplacement of the module inventory. As with the Proposed Action, no cumulative impact would be likely from the procurement and use of hazardous materials at the repository.

8.2.12.2 Cumulative Impacts from Inventory Module 1 or 2 and Other Federal, Non-Federal, and Private Actions

Waste operations at the Nevada Test Site (disposing of Nevada Test Site-generated waste and accepting waste from other sites in accordance with decisions from the Waste Management Programmatic EIS) could present a cumulative impact. Section 8.2.12.1 discusses the impact on Test Site facilities from disposal of repository waste and waste that is already projected to be disposed of at the Test Site.

If Nevada Test Site landfills are used to dispose of nonrecyclable construction and demolition debris and sanitary and industrial waste, the landfills would be required to operate past their projected operating lives and to expand as needed (the degree of expansion would depend on how much waste was disposed of at the repository facilities).

Low-level waste capacity at the Nevada Test Site is sufficient to accommodate the repository-generated waste and the projected volume of 1.1 million cubic meters of waste from the Test Site, although the facility might have to use some of its reserve capacity to meet the combined need.

8.2.13 ENVIRONMENTAL JUSTICE

As discussed in Chapter 4, Section 4.1.13, the environmental justice analysis brings together the results of all resource and feature analyses to determine (1) if an activity would have substantial environmental impacts and (2) if those substantial impacts would have disproportionately high and adverse human health or environmental effects on minority or low-income populations. DOE determined that cumulative impacts from Inventory Module 1 or 2 along with those expected from other Federal, non-Federal, and private actions would not produce cumulative adverse impacts to any surrounding populations, which would include minority and low-income populations. Evaluation of subsistence lifestyles and cultural values has confirmed that these factors would not change the conclusion that the absence of high and adverse impacts for the general population means there would be no disproportionately high and adverse impacts on minority or low-income communities. No substantial impacts were identified; therefore, cumulative impacts from Inventory Module 1 or 2 and other Federal, non-Federal, and private actions would not cause environmental justice concerns.

DOE recognizes that Native American people living in areas near Yucca Mountain have concerns about the protection of traditions and the spiritual integrity of the land that extend to the propriety of the Proposed Action, and that the implementation of the Proposed Action would continue restrictions on access to the site. Chapter 4, Section 4.1.3.4, discusses these views and beliefs.

8.3 Cumulative Long-Term Impacts in the Proposed Yucca Mountain Repository Vicinity

This section describes results from the long-term cumulative impact analysis that DOE conducted for Inventory Modules 1 and 2 (Section 8.3.1) and for past, present, and reasonably foreseeable future actions at the Nevada Test Site, and past actions at the Beatty low-level radioactive waste site (Section 8.3.2).

8.3.1 INVENTORY MODULE 1 OR 2 IMPACTS

The analysis of long-term performance for Inventory Modules 1 and 2 used the same methodology described in Chapter 5 and Appendix I for the Proposed Action to estimate potential human health impacts from radioactive and chemically toxic material releases through waterborne and airborne pathways. Section 8.3.1.1 presents the radioactive and chemically toxic material source terms for Inventory Modules 1 and 2, and Sections 8.3.1.2 and 8.3.1.3 present the results of the analysis for Inventory Modules 1 and 2, respectively.

In addition to long-term human health impacts from radioactive and chemically toxic material releases, the other potential long-term impact identified following repository closure involve biological resources. Though the surface area affected by heat rise would be larger for Inventory Module 1 or 2, the amount of heat per unit area would be constant for a given repository operating mode (lower- or higher-temperature), and, therefore, the small ground surface temperature increase would be the same. Thus, long-term biological effects of Module 1 or 2 from heat generated by waste packages that would potentially raise ground surface temperatures would be the same as those described in Chapter 5, Section 5.9 for the Proposed Action.

8.3.1.1 Radioactive and Chemically Toxic Material Source Terms for Inventory Modules 1 and 2

For calculations of long-term performance impacts, the radioactive material inventory of individual waste packages for commercial spent nuclear fuel, high-level radioactive waste, and DOE spent nuclear fuel under Inventory Modules 1 and 2 would be identical to the radioactive material inventory under the

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Proposed Action for the same waste categories. Inventory Module 2 includes an additional waste category for Greater-Than-Class-C and Special-Performance-Assessment-Required wastes. This category includes a different category of waste package with its own radioactive material inventory. This waste was simulated with 601 idealized waste packages. The inventory used for each modeled waste package is an averaged radioactive material inventory of each waste category (commercial spent nuclear fuel, DOE spent nuclear fuel, high-level radioactive waste, and Greater-Than-Class-C and Special-Performance-Assessment-Required wastes). More waste packages would be used for Inventory Modules 1 and 2 than for the Proposed Action to accommodate the expanded inventories. Table 8-42 lists the number of waste packages used in the analysis of long-term performance calculations for the Proposed Action and Modules 1 and 2.

Table 8-42. Number of idealized waste packages used in analysis of long-term performance calculations.[a]

Modeled inventory	Commercial SNF[b]	Codisposal (DOE SNF and HLW[c])	GTCC and SPAR[d]	Total
Proposed Action	7,860	3,910	0	11,770
Inventory Module 1	11,754	4,877	0	16,631
Inventory Module 2	11,754	4,877	601	17,232

a. The idealized waste packages in the simulation (model) are based on the inventory abstraction in Appendix I, Section I.3. While the total inventory is represented by the material in the idealized waste packages, the actual number of waste packages emplaced in the proposed repository would be different.
b. SNF = spent nuclear fuel.
c. HLW = high-level radioactive waste.
d. GTCC = Greater-Than-Class-C; SPAR = Special-Performance-Assessment-Required.

IDEALIZED WASTE PACKAGES

The number of waste packages used in the performance assessment simulations do not exactly match the number of actual waste packages specified in DIRS 150558-CRWMS M&O (2000, Section 6.2).

The TSPA model uses two types of *idealized waste packages* (commercial spent nuclear fuel package and codisposal package), representing the averaged inventory of all the actual waste packages used for a particular waste category.

While the number of idealized waste packages varies from the number of actual waste packages in DIRS 150558-CRWMS M&O (2000, Section 6.2), the total radionuclide inventory represented by all of the idealized waste packages collectively is representative of the total inventory, for the radionuclides analyzed, given in Appendix A of this EIS for the purposes of analysis and long-term performance. *The abstracted inventory is designed to be representative for purposes of analysis of long-term performance and cannot necessarily be used for any other analysis, nor can it be directly compared to any other abstracted inventory used for other analyses in this EIS.*

As listed in Table 8-42, Inventory Module 2 differs from Inventory Module 1 only by the addition of 601 Greater-than-Class-C and Special-Performance-Assessment-Required idealized waste packages. Table 8-43 lists the inventory of the Greater-than-Class-C and Special-Performance-Assessment-Required waste packages under Inventory Module 2.

A screening analysis documented in Appendix I, Section I.6.1, showed that the only chemical materials of concern for the 10,000-year analysis period were those that would be released as the external waste package Alloy-22 layer and the waste package support pallet materials corroded. This is because most waste packages would be intact for more than 10,000 years after closure (the results of the analysis of

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Table 8-43. Abstracted inventory (grams) of radionuclides passing the screening analysis in each idealized waste package for Greater-Than-Class-C and Special-Performance-Assessment-Required wastes under Inventory Module 2.[a]

Isotope	Inventory
Actinium-227	0
Americium-241	40
Americium-243	0.00151
Carbon-14	28.9
Cesium-137	771
Iodine-129	0.000705
Nickel-63	0
Neptunium-237	0
Protactinium-231	0
Lead-210	0
Plutnium-238	1.56
Plutonium-239	2,860
Plutonium-240	0.0123
Plutonium-241	0.0207
Plutonium-242	0.00614
Radium-226	0.0504
Radium-228	0
Strontium-90	0.82
Technetium-99	568
Thorium-229	0
Thorium-230	0
Thorium-231	0
Uranium-232	0.00000287
Uranium-233	0.00419
Uranium-234	0
Uranium-235	0
Uranium-236	0

a. The idealized waste packages in the simulation (model) are based on the inventory abstraction in Appendix I, Section I.3. While the total inventory is represented by the material in idealized waste packages, the actual number of waste packages emplaced in the proposed repository would be different.

long-term performance for radionuclides described in Appendix I, Section I.5, show that, at most, only three waste packages would be breached before 10,000 years, due to improper heat treatment, under the Proposed Action). Therefore, accounting for the quantities of materials in the engineered barrier system, but not in the waste packages, and accounting for toxicity to humans, the only chemical materials of concern would be chromium, nickel, molybdenum, and vanadium. The inventories of these chemical materials in the engineered barrier system for the Proposed Action and Inventory Modules 1 and 2 are listed in Table 8-44. These are essentially the only inventories available for mobilization and transport within 10,000 years after closure; the inventories of chemical materials in the waste packages would not begin to degrade until waste package failure. Further information on the inventory of chemical materials of concern is provided in Appendix I, Section I.3.

The only radionuclide that would have a relatively large inventory and a potential for gas transport is carbon-14. Iodine-129 can exist in a gas phase, but it is highly soluble and, therefore, would be likely to dissolve in groundwater rather than migrate as a gas. Radon-222 is a gas, but would decay to a solid isotope before escaping from the repository region (see Appendix I, Section I.7.3). After the carbon-14 escaped from the waste package, it could flow through the fractured and porous rock in the form of carbon dioxide. About 2 percent of the carbon-14 in commercial spent nuclear fuel is in gas in the space (or gap) between the fuel and the cladding around the fuel (DIRS 103446-Oversby 1987, p. 92). There are 1.37 grams of carbon-14 in an abstracted commercial spent nuclear fuel waste package (see Appendix I, Table I-5). This represents 6.11 curies per waste package. Since 2 percent of the total is gaseous, the gaseous inventory consists of 0.122 curie of carbon-14 per commercial spent nuclear fuel waste package. There would be additional carbon-14 activity associated with Inventory Module 2, in relation to Module 1, resulting from neutron irradiation of the core shroud metal. The carbon-14 would be unlikely to be present as gaseous carbon dioxide that could be released to the environment and is therefore not included in Table 8-45.

Table 8-44. Total quantities of waterborne chemicals of concern in the engineered barrier system under the Proposed Action and Inventory Modules 1 and 2 (kilograms).[a,b]

Modeled inventory	Chromium	Molybdenum	Nickel	Vanadium
Proposed Action	23,735,000	17,307,000	60,797,000	377,600
Inventory Module 1	34,695,000	25,301,000	88,879,000	552,000
Inventory Module 2	34,951,000	25,490,000	89,545,000	556,000

a. To convert kilograms to pounds, multiply by 2.2046.
b. See screening analysis in Appendix I, Section I.3.2.

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Table 8-45. Total **gaseous** carbon-14 in the repository from commercial spent nuclear fuel for the Proposed Action and Inventory Modules 1 and 2 (curies).

Modeled inventory	Quantity[a]
Proposed Action	959
Inventory Module 1	1,430
Inventory Module 2	1,430

a. Based on 0.122 curies of carbon-14 per commercial spent nuclear fuel waste package.

8.3.1.2 Impacts for Inventory Module 1

The human-health impacts from Inventory Module 1 for radioactive materials and chemically toxic materials are discussed in this section.

8.3.1.2.1 *Waterborne Radioactive Material Impacts*

The DOE used the modeling methods described for the Proposed Action in Chapter 5 (and in greater detail in Appendix I) to calculate the impacts both for an individual and the local population resulting from groundwater releases of radioactive material for 10,000 years and 1 million years following repository closure for Inventory Module 1.

8.3.1.2.1.1 Higher-Temperature Operating Mode. Table 8-46 lists the estimated impacts for an individual for the higher-temperature operating mode under the Proposed Action and Inventory Module 1. The peak annual individual dose for the first 10,000 years shows slightly higher values for the mean and 95th percentile of the Proposed Action than for Module 1. Because Module 1 has a higher inventory, this would seem like an incorrect trend. However, note that in the first 10,000 years releases are dominated by at most about 3 waste package failures due to a manufacturing defect (improper heat treatment). Thus, the release is essentially insensitive to inventory and the differences in Table 8-46 between the Proposed Action and Module 1 are merely the result of slightly different statistical outcomes in the 300 simulations.

Table 8-46. Impacts for an individual from groundwater releases of radionuclides during 10,000 years after repository closure for the higher-temperature repository operating mode under the Proposed Action and Inventory Module 1.

		Mean			95th-percentile		
Modeled inventory	Individual	Peak annual individual dose (millirem)	Time of peak (years)	Probability of a LCF[a]	Peak annual individual dose (millirem)	Time of peak (years)	Probability of a LCF[a]
Proposed Action	At RMEI location[b]	0.00002[c]	4,900	6×10^{-10}	0.0001[d]	4,900	4×10^{-9}
	At 30 kilometers[e]	~0[f]	NC[g]	~0	~0[f]	NC[g]	~0
	At discharge location[h]	~0[f]	NC[g]	~0	~0[f]	NC[g]	~0
Inventory Module 1	At RMEI location[b]	0.00003[c]	4,900	1×10^{-9}	0.002[d]	4,100	6×10^{-9}
	At 30 kilometers[d]	~0[f]	NC[g]	~0	~0[f]	NC[g]	~0
	At discharge location[h]	~0[f]	NC[g]	~0	~0[f]	NC[g]	~0

a. LCF = latent cancer fatality; incremental lifetime (70 years) risk of contracting a fatal cancer, assuming a risk of 0.0005 latent cancer fatality per rem for members of the public (DIRS 101856-NCRP 1993, p. 31).
b. The RMEI location, defined in 40 CFR Part 197, is where the predominant groundwater flow path crosses the boundary of the controlled area and is approximately 18 kilometers (11 miles) downgradient from the repository. The maximum allowable peak of the mean annual individual dose for 10,000 years at this distance is 15 millirem.
c. Based on 300 simulations of total system performance, using random samples of uncertain parameters.
d. Represents a value for which 285 out of the 300 simulations yielded a smaller value.
e. To convert kilometers to miles, multiply by 0.62137.
f. Values would be lower than the small values computed for the RMEI location.
g. NC = not calculated (peak time would be greater than time given for the RMEI location).
h. 60 kilometers (37 miles) at Franklin Lake Playa.

Table 8-47 lists the impacts to the population during the first 10,000 years after repository closure for both the Proposed Action and Inventory Module 1 for the higher-temperature operating mode. These impacts were calculated on the same population basis used for the Proposed Action calculations presented in Chapter 5, that is a population size was based on the projected population numbers for 2035 in Figure 3-25 in Chapter 3. For these calculations, the analysis assumed that no contaminated groundwater

Table 8-47. Population impacts from groundwater releases of radionuclides during 10,000 years after repository closure for the higher-temperature repository operating mode under the Proposed Action and Inventory Module 1.[a]

Modeled inventory	Case	Mean		95th-percentile	
		Population dose (person-rem)	Population LCFs[b]	Population dose (person-rem)	Population LCFs[b]
Proposed Action	Peak 70-year lifetime	0.006	0.000003	0.04	0.00002
	Integrated over 10,000 years	0.5	0.0002	0.6	0.0003
Inventory Module 1	Peak 70-year lifetime	0.01	0.000005	0.06	0.00003
	Integrated over 10,000 years	0.7	0.0003	0.8	0.0004

a. Based on 300 simulations of total system performance for each location, using random samples of uncertain parameters.
b. LCF = latent cancer fatality; expected number of cancer fatalities for populations, assuming a risk of 0.0005 latent cancer fatality per rem for members of the public (DIRS 101856-NCRP 1993, p. 31).

would reach populations in any regions to the north of Yucca Mountain. Therefore, populations in the sectors north of the due east and due west sectors were not considered to be exposed.

- 47 people would be exposed at the Reasonably Maximally Exposed Individual (RMEI) location [approximately 18 kilometers (11 miles)] downgradient from the repository [includes sectors from 12 to 28 kilometers (7 to 27 miles)].

- 4,200 people would be exposed at about 30 kilometers (19 miles) downgradient from the potential repository [includes sectors from 28 to 44 kilometers (17 to 27 miles)].

- 69,500 people would be exposed at the discharge location, about 60 kilometers (37 miles) downgradient of the potential repository [includes sectors from 44 to 80 kilometers (27 to 50 miles)].

Thus, approximately 74,000 people would be exposed to contaminated groundwater. This stylized population dose analysis assumed that people would continue to live in the locations being used at present. This assumption is consistent with the recommendation made by the National Academy of Sciences (DIRS 100018-National Research Council 1995, all) because it is impossible to make accurate predictions of future lifestyles and residence locations far into the future.

The population impacts would be greater than the impacts for the Proposed Action under the higher-temperature operating mode. For example, the population dose in the 70-year period of maximum impacts would be about 25 percent greater for Module 1 than for the Proposed Action at the mean level and the same 70-year period.

The values in Table 8-47 include a scaling factor for water use. The performance assessment transport model calculated the annual individual dose assuming the radionuclides dissolved in water that flowed through the unsaturated zone of Yucca Mountain would mix in an average of 2.4 million cubic meters (1,940 acre-feet) (DIRS 155950-BSC 2001, p. 13-42) per year in the saturated zone aquifer. This compares to an annual water use in the Amargosa Valley of about 17.1 million cubic meters (13,900 acre-feet) (DIRS 155950-BSC 2001, p. 13-42). The analysis diluted the concentration of the nuclides in the 2.4 million cubic meters of water throughout the 17.1 million cubic meters of water prior to calculating the population dose.

Table 8-48 lists the peak annual individual dose and time of peak for 1 million years after repository closure for both Inventory Module 1 and the Proposed Action for the higher-temperature operating mode. The impacts would follow the same pattern as those for the first 10,000 years after repository closure listed in Table 8-47, with the impacts for Module 1 about 60 percent greater than those for the Proposed Action.

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Table 8-48. Impacts to an individual from groundwater releases of radionuclides for 1 million years after repository closure for the higher-temperature repository operating mode under the Proposed Action and Inventory Module 1.

		Mean		95th-Percentile	
Modeled inventory	Individual	Peak annual individual dose (millirem)	Time of peak (years)	Peak annual individual dose (millirem)	Time of peak (years)
Proposed Action	At RMEI location[a]	150[b]	480,000	620[c]	410,000
	At 30 kilometers[d]	100[e]	NC[f]	420[e]	NC[f]
	At discharge location[g]	59[e]	NC[f]	240[e]	NC[f]
Inventory Module 1	At RMEI location[a]	240[b]	480,000	980[c]	480,000
	At 30 kilometers[d]	160[e]	NC[f]	660[e]	NC[f]
	At discharge location[g]	90[e]	NC[f]	450[e]	NC[f]

a. The RMEI location, defined in 40 CFR Part 197, is where the predominant groundwater flow path crosses the boundary of the controlled area and is approximately 18 kilometers (11 miles) downgradient from the repository.
b. Based on 300 simulations of total system performance for each location, using random samples of uncertain parameters.
c. Represents a value for which 285 out of the 300 simulations yielded a smaller value.
d. To convert kilometers to miles, multiply by 0.62137.
e. Estimated using scale factors as described in Chapter 5, Section 5.4.1.
f. NC = not calculated (peak time would be greater than time given for the RMEI location).
g. 60 kilometers (37 miles) at Franklin Lake Playa.

WHY ARE THE MEAN IMPACTS SOMETIMES HIGHER THAN THE 95TH-PERCENTILE IMPACTS?

The *mean* impact is the arithmetic average of the 300 impact results from simulations of total-system performance. The mean is not the same as the 50th-percentile value (the 50th-percentile value is called the *median*) if the distribution is *skewed*.

The performance results reported in this EIS come from highly skewed distributions. In this context, *skewed* indicates that there are a few impact estimates that are much larger than the rest of the impacts. When a large value is added to a group of small values, the large value dominates the calculation of the mean. The simulations reported in this EIS have mean impacts that are occasionally above the 90th-percentile and occasionally above the 95th percentile.

With respect to groundwater protection standards set forth in 40 CFR Part 197.30, both the mean and the 95th percentile estimated levels during the 10,000-year regulatory period are hundreds of thousands of times less than the regulatory limits (see Table 8-49) for both the Proposed Action and Inventory Module 1.

8.3.1.2.1.2 Lower-Temperature Operating Mode. Impacts were not calculated for the lower-temperature operating mode under Inventory Module 1 or 2 because of the lack of differentiation between higher-temperature and lower-temperature operating modes under the Proposed Action (see Chapter 5). Comparison of the mean individual dose history at the RMEI location for the lower- and higher-temperature operating modes is shown in Figure 8-4. For the Proposed Action, the individual dose for the lower-temperature operating mode at a given location would be about the same as that for the higher-temperature operating mode, with the long-term peak slightly greater for the higher-temperature operating mode. Calculations for Inventory Module 1 produce a similar response. Given the similarity of impacts, and that the lower-temperature operating mode impacts are generally bounded by the higher-temperature operating mode impacts, it was deemed unnecessary to perform detailed simulations for the lower-temperature operating mode under Inventory Module 1. The results would be similar to, but less than, those for the higher-temperature operating mode under Inventory Module 1, as reported in Section 8.3.1.2.1.1.

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Table 8-49. Comparison of nominal scenario long-term consequences at the RMEI location[a] to groundwater protection standards during 10,000 years following repository closure for the higher-temperature repository operating mode under the Proposed Action and Inventory Module 1.

Modeled inventory	Radionuclide or type of radiation emitted	EPA Limit[b]	Mean peak[c]	95th-percentile peak[d]
Proposed Action	Combined radium-226 and radium-228,[e] picocuries per year	5	1.0 (1×10^{-11})[f]	1.0 (2×10^{-11})
	Gross alpha activity (including radium-226 but excluding radon and uranium),[e] picocuries per year	15	0.4 (2×10^{-8})	0.4 (1×10^{-8})
	Combined beta and photon emitting radionuclides,[g] millirem per year to the whole body or any organ, based on drinking 2 liters of water per day from the representative volume	4	2×10^{-5}	1×10^{-4}
Inventory Module 1	Combined radium-226 and radium-228,[e] picocuries per year	5	1.0 (3×10^{-10})	1.0 (3×10^{-11})
	Gross alpha activity (including radium-226 but excluding radon and uranium),[e] picocuries per year	15	0.4 (3×10^{-8})	0.4 (4×10^{-8})
	Combined beta and photon emitting radionuclides,[g] millirem per year to the whole body or any organ, based on drinking 2 liters of water per day from the representative volume	4	3×10^{-5}	2×10^{-4}

a. The RMEI location, defined in 40 CFR Part 197, is where the predominant groundwater flow path crosses the boundary of the controlled area and is located approximately 18 kilometers (11 miles) downgradient from the repository.
b. Environmental Protection Agency limits set forth in 40 CFR Part 197.30.
c. Based on 300 simulations of total system performance, each using random samples of uncertain parameters.
d. Represents a value for which 285 out of the 300 simulations yielded a smaller value.
e. Includes natural background radiation.
f. Value in parentheses is the incremental increase over background radiation that would be attributable to the potential repository.
g. This represents a bounding (overestimate) of the maximum dose to any organ because the different radionuclides would affect different organs preferentially.

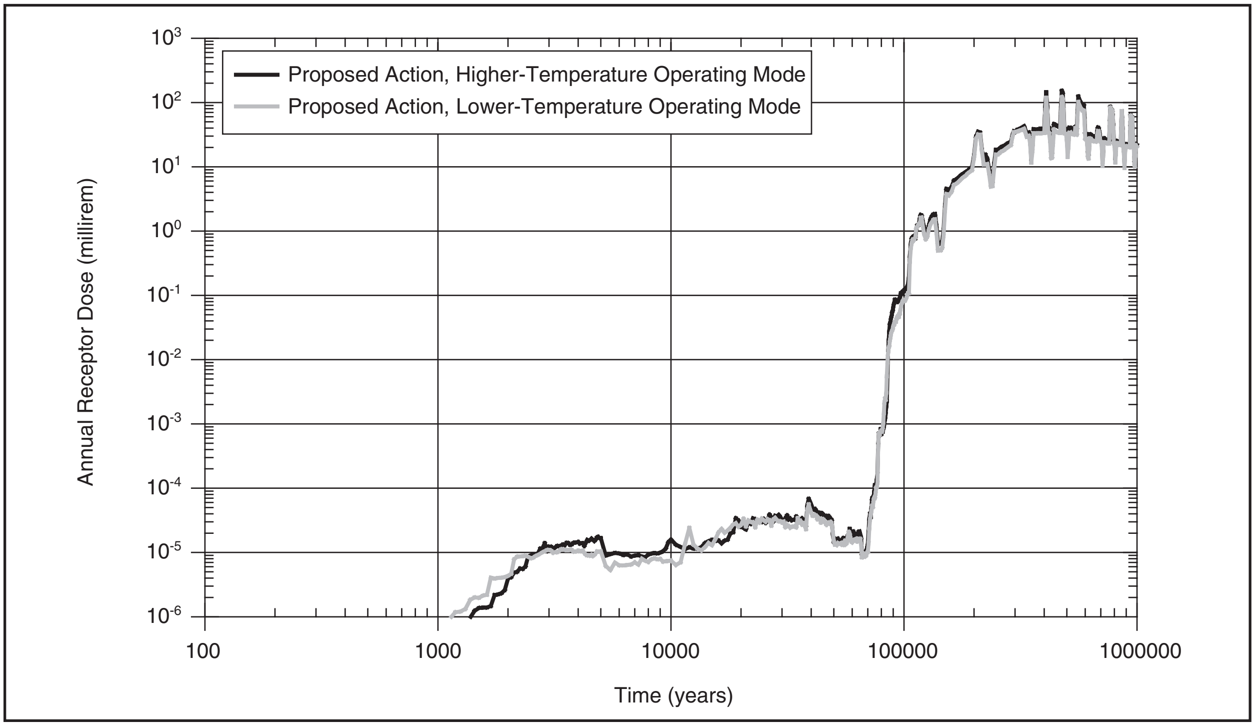

Figure 8-4. Comparison of mean annual individual dose (based on 300 simulations of total system performance, each using random samples of uncertain parameters) at the RMEI location for the higher- and lower-temperature operating modes. (Note use of logarithmic scale for both axes.)

8.3.1.2.2 *Waterborne Chemically Toxic Material Impacts*

A number of nonradioactive materials that DOE would place in the repository are hazardous to human health at high concentrations in water. This section examines the consequences to individuals in the Amargosa Desert from releases of these nonradioactive materials under Inventory Module 1.

The inventory of chemically toxic materials that would be emplaced in the repository under the Proposed Action is identified by element in Appendix I, Section I.3. Based on this inventory, a screening analysis (described in Appendix I, Section I.6.1) identified which of the chemically toxic materials might pose a risk to human health. Only chromium, molybdenum, nickel, and vanadium were identified as potentially posing such a risk, and these elements were further evaluated in a bounding consequence analysis, as described in Appendix I, Section I.6.2. The analysis was performed under the conservative assumption that all chromium dissolves in hexavalent form. The results of the bounding analysis are summarized for both the Proposed Action and Inventory Module 1 in Table 8-50. In some cases a Maximum Containment Level or Maximum Contaminant Level Goal was available for comparison to the calculated concentration. In other cases, only an Oral Reference Dose was available. The Oral Reference Dose can be compared to intake that would result for a 70-kilogram (154-pound) person drinking 2 liters (0.53 gallon) of water per day. More detail on these comparative measures can be found in Chapter 5, Section 5.6, and Appendix I, Section I.6.2.5.

Table 8-50. Peak concentration of waterborne chemical materials released during 10,000 years after closure estimated using bounding calculations for the Proposed Action and Inventory Module.

Modeled inventory	Material	Estimated concentration in well water (milligram per liter)	Maximum Contaminant Level Goal (milligram per liter)	Estimated intake rate for a 70-kilogram person (milligram per kilogram per day)	Oral Reference Dose (milligram per kilogram per day)
Proposed Action	Chromium (VI)	0.01	0.1[a]	0.0004	0.005[b]
	Molybdenum	0.009	NA[c]	0.0003	0.005[d]
	Nickel	0.04	NA	0.001	0.02[e]
	Vanadium	0.0002	NA	0.000006	0.007[f]
Inventory Module 1	Chromium (VI)	0.02	0.1[a]	0.0006	0.005[b]
	Molybdenum	0.01	NA	0.0004	0.005[d]
	Nickel	0.05	NA	0.002	0.02[e]
	Vanadium	0.0003	NA	0.000009	0.007[f]

a. 40 CFR 191.51.
b. DIRS 148224-EPA (1999, all).
c. NA = not available.
d. DIRS 148228-EPA (1999, all).
e. DIRS 148229-EPA (1999, all).
f. DIRS 103705-EPA (1997, all).

Because the bounding concentration of chromium, molybdenum, nickel, and vanadium in well water is calculated to be below the Maximum Contaminant Level Goal or yield intakes well below the Oral Reference Dose for Inventory Module 1, there is no further need to refine the calculation to account for physical processes that would limit mobilization of this material or delay or dilute it during transport in the geosphere.

8.3.1.2.3 *Atmospheric Radioactive Material Impacts*

Using the analysis methods described in Chapter 5, Section 5.5, DOE estimated the impacts of carbon-14 releases to the atmosphere within 10,000 years past closure for Inventory Module 1. As explained in Appendix I, Section I.7.1, the maximum release rate to the ground surface for this period is the same for both Inventory Modules 1 and 2 as for the Proposed Action. Therefore, there would be no incremental atmospheric radioactive material impacts for Inventory Module 1 for the Proposed Action.

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8.3.1.3 INCREMENTAL IMPACTS FOR INVENTORY MODULE 2

DOE addressed the long-term consequences from Inventory Module 2 by analyzing the effects of disposing waste packages containing Greater-Than-Class-C and Special-Performance-Assessment-Required wastes in addition to the material in Inventory Module 1. Table 8-43 lists the average inventory of the additional waste packages containing Greater-Than-Class-C and Special-Performance-Assessment-Required wastes. The following sections discuss these impacts in terms of waterborne radioactive releases, chemically toxic materials waterborne release, and atmospheric radioactive material releases.

8.3.1.3.1 *Waterborne Radioactive Material Impacts*

The addition of Greater-Than-Class-C and Special-Performance-Assessment-Required wastes is the only difference between Inventory Modules 1 and 2. Inventory Module 2 was modeled as an incremental inventory; specifying only the Greater-Than-Class-C and Special-Performance- Assessment-Required waste as the radionuclide inventory. The results of the incremental inventory simulations constitute the additional impacts of Inventory Module 2 over those of Module 1. In addition, they represent the dose attributable solely to the Greater-Than-Class-C and Special- Performance-Assessment-Required waste.

Table 8-51 lists the incremental consequences for an individual from the Greater-Than-Class-C and Special-Performance-Assessment-Required wastes in Inventory Module 2 during 10,000 years and 1 million years following repository closure. Peak impacts from waterborne radioactive materials for Module 2 would be less than 1 percent higher for 1,000,000 years after repository closure. For the first 10,000 years following the repository closure, the Module 2 impact would remain very small (mean annual individual dose of 0.0007 millirem, compared to the Environmental Protection Agency standard of 15 millirem for this period as defined in 40 CFR Part 197).

Table 8-51. Incremental increase (millirem) in mean peak individual annual dose at the RMEI location[a] under Inventory Module 2 over the mean peak individual annual dose under Inventory Module 1 during 10,000 and 1 million years after repository closure.

Postclosure period	Incremental Increase[b]
10,000 years	0.0007
1,000,000 years	0.3

a. The RMEI location, defined in 40 CFR Part 197, is where the predominant groundwater flow path crosses the boundary of the controlled area and is approximately 18 kilometers (11 miles) downgradient from the repository.

b. Based on 300 simulations each for Inventory Modules 1 and 2 using random samples of uncertain parameters.

8.3.1.3.2 *Waterborne Chemically Toxic Material Impacts*

A number of nonradioactive materials that DOE would place in the repository are hazardous to human health at high concentrations in water. This section examines the consequences to individuals in the Amargosa Desert from releases of these nonradioactive materials under Inventory Module 2.

The inventory of chemically toxic materials that would be emplaced in the repository under the Proposed Action is identified by element in Appendix I, Section I.3. Based on this inventory, a screening analysis (described in Appendix I, Section I.6.1.) identified which of the chemically toxic materials could pose a risk to human health. Only chromium, molybdenum, nickel, and vanadium were identified as posing such a risk, and these elements were further evaluated in a bounding consequence analysis, as described in Appendix I, Section I.6.2. The results of the bounding analysis are summarized for both the Proposed Action and Inventory Module 2 in Table 8-52. In some cases a Maximum Contaminant Level Goal was available for comparison to the calculated concentration. In other cases, only an Oral Reference Dose was available. The Oral Reference Dose can be compared to the intake that would result for a 70-kilogram (154-pound) person drinking 2 liters (0.53 gallon) of water per day. More detail on these comparative measures can be found in Chapter 5, Section 5.6, and Appendix I, Section I.6.2.5.

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Table 8-52. Peak concentration of waterborne chemical materials released during 10,000 years after closure estimated using bounding calculations for the Proposed Action and Inventory Module 2.

Modeled inventory	Material	Estimated concentration in well water (milligram per liter[a])	Maximum Contaminant Level Goal (milligram per liter)	Estimated intake rate for a 70-kilogram person (milligram per kilogram per day)	Oral Reference Dose (milligram per kilogram per day)
Proposed Action	Chromium (VI)	0.01	0.1[a]	0.0004	0.005[b]
	Molybdenum	0.009	NA[c]	0.0003	0.005[d]
	Nickel	0.04	NA	0.001	0.02[e]
	Vanadium	0.0002	NA	0.000006	0.007[f]
Inventory Module 2	Chromium (VI)	0.02	0.1	0.0006	0.005[b]
	Molybdenum	0.01	NA	0.0004	0.005[d]
	Nickel	0.06	NA	0.002	0.02[e]
	Vanadium	0.0003	NA	0.00001	0.007[f]

a. 40 CFR 191.51.
b. DIRS 148224-EPA (1999, all).
c. NA = not available.
d. DIRS 148228-EPA (1999, all).
e. DIRS 148229-EPA (1999, all).
f. DIRS 103705-EPA (1997, all).

Because the bounding concentration of chromium, molybdenum, nickel, and vanadium in well water is calculated to be below the Maximum Containment Level Goal or yield intakes well below the Oral Reference Dose for Inventory Module 2, there is no further need to refine the calculation to account for physical processes that would limit mobilization of this material or delay or dilute it during transport in the geosphere.

The incremental (that is, the increase in) consequences for an individual from the Greater-Than-Class-C and Special-Performance-Assessment-Required wastes in Inventory Module 2 over Inventory Module 1 during 10,000 years and 1 million years following repository closure is 4 percent for all four waterborne chemical materials of concern (chromium, molybdenum, nickel, and vanadium).

8.3.1.3.3 *Atmospheric Radioactive Material Impacts*

There would be no incremental impact for airborne carbon-14 releases for Inventory Module 2. None of the additional waste packages would contain a waste form in which carbon-14 would exist in gaseous form (that is, as carbon dioxide). As for the Proposed Action and Inventory Module 1, radon-222 would be released as a gas but would decay to a solid isotope before escaping from the repository region (see Appendix I, Section I.7.3).

8.3.2 CUMULATIVE IMPACTS FROM OTHER FEDERAL, NON-FEDERAL, AND PRIVATE ACTIONS

This section discusses potential cumulative impacts from other Federal, non-Federal, and private actions that could contribute to doses at the locations considered in the performance assessment of the Yucca Mountain Repository. The actions identified with the potential for long-term cumulative impacts are past, present, and reasonably future actions at the Nevada Test Site and past actions at the low-level radioactive waste disposal facility near Beatty, Nevada.

8.3.2.1 Past, Present, and Reasonably Foreseeable Future Actions at the Nevada Test Site

Historically, the primary mission of the Nevada Test Site was to conduct nuclear weapons tests. Nuclear weapons testing and other activities have resulted in radioactive contamination and have the potential for radioactive and nonradioactive contamination of some areas of the Nevada Test Site. These areas and the associated contamination and the potential for contamination were evaluated for potential cumulative impacts with postclosure impacts from the proposed Yucca Mountain Repository. This section discusses these Nevada Test Site activities, the locations where these activities occurred, and the potential for cumulative long-term impacts with the repository.

Unless otherwise identified, DOE derived the information in this section from the Nevada Test Site Final EIS (DIRS 101811-DOE 1996, all). The Yucca Mountain site is in the southwestern portion of the Nevada Test Site along its western boundary, as shown in Figure 8-2.

At the Nevada Test Site, seven categories of activities have resulted in radioactive contamination or have the potential to result in radioactive and nonradioactive contamination:

1. *Atmospheric Weapons Testing.* One hundred atmospheric detonations occurred before the signing of the Limited Test Ban Treaty in August 1963. Atmospheric tests included detonations at ground level, from towers or balloons, or from airdrops.

2. *Underground Nuclear Testing.* Approximately 800 underground nuclear tests have occurred at the Nevada Test Site. Chapter 3, Figure 3-2 shows the locations of these tests in relation to Yucca Mountain. They included deep underground tests to study weapons effects, designs, safety, and reliability, and shallow underground tests to study the peaceful application of nuclear devices for cratering.

3. *Safety Tests.* Between 1954 and 1963, 16 above-ground tests studied the vulnerability of weapons designs to possible accident scenarios.

4. *Nuclear Rocket Development Station.* Twenty-six experimental tests of reactors, nuclear engines, ramjets, and nuclear furnaces occurred between 1959 and 1973. Figure 8-3 shows the location of the Nuclear Rocket Development Station.

5. *Shallow Land Radioactive Waste Disposal.* DOE disposed of some radioactive waste generated during testing in shallow cells, pits, and trenches. Because of the significant thickness of alluvial material and high mean annual temperatures and low precipitation under the current climate regime, downward advection of groundwater to the water table is highly unlikely. Therefore, shallow burial continues to be an important waste disposal activity at the Nevada Test Site (DIRS 155159-REECo, 1994, all; DIRS 108774-Tyler et al. 1996, all).

Section 8.3.2.1.3 discusses present and potential future low-level radioactive waste disposal activities.

6. *Crater Disposal.* DOE disposed of contaminated soils and equipment collected during the decontamination of atmospheric testing areas and the consolidation of radioactively contaminated structures, and other bulk wastes, in subsidence craters at Yucca Flat in Area 3. Figure 8-3 shows the location of Area 3 on the Nevada Test Site.

7. *Greater Confinement Disposal.* In 1981, Greater Confinement Disposal began at Area 5 for low-level radioactive wastes not suitable for shallow land disposal. This waste includes some transuranic radionuclides. Figure 8-3 shows the location of Area 5 on the Nevada Test Site.

Table 8-53 lists the approximate inventory for each of these categories. Atmospheric testing, shallow underground testing, safety testing, and nuclear rocket development all resulted in a small (less-than-40-curie) source term, which would not contribute substantially to cumulative impacts. Additionally, the inventories represented by crater disposal and shallow-land disposal were determined to not be important to cumulative impact considerations. Only the deep underground testing and greater confinement

Table 8-53. Summary of radioactivity on the Nevada Test Site (January 1996).[a]

Source	Area	Environmental media	Major known isotopes or wastes	Depth range	Approximate inventory (curies)
Atmospheric weapons testing	Aboveground nuclear weapon proving area	Surficial soils and test structures	Americium, cesium, cobalt, plutonium, europium, strontium	At land surface	20
Underground testing: shallow underground tests	Underground nuclear testing areas	Soils and alluvium	Americium, cesium, cobalt, europium, plutonium, strontium	Less than 61 meters[b]	1 at land surface; unknown at depth
Underground testing: deep underground tests	Underground nuclear testing areas	Soils, alluvium, and consolidated rock	Tritium, fission, and activation products	Typically less than 640 meters, but might be deeper	130 million[c]
Safety tests	Aboveground experimental areas	Surficial soils	Americium, cesium, cobalt, plutonium, strontium	Less than 0.9 meter	35
Nuclear rocket development area	Nuclear rocket motor, reactor, and furnace testing area	Surficial soils	Cesium, strontium	Less than 3 meters	1
Shallow land disposal	Waste disposal landfills	Soils and alluvium	Dry-packaged low-level and mixed wastes	Less than 9 meters	500,000[d,e]
Crater disposal	Test-induced subsidence crater with sidewalls, cover, and drainage	Soils and alluvium	Bulk contaminated soils and equipment	Less than 30 meters	1,250[d,f]
Greater confinement disposal	Monitored underground waste disposal	Soils and alluvium	Tritium, americium	37 meters	9.3 million[d,g]

a. Source: DIRS 101811-DOE (1996, p. 4-6). This table uses information and terminology from that document and is for information purposes only.
b. To convert meters to feet, multiply by 3.2808.
c. Source: DIRS 157116-Bowen et al. (2001, Table V, p. 21)
d. Inventory at time of disposal (not corrected for decay).
e. Inventory does not include prospective future low-level radioactive and mixed waste disposal (see Section 8.3.2.1.3).
f. Volume of waste considered for inventory was approximately 205,000 cubic meters (7.25 million cubic feet).
g. Volume of waste considered for inventory was approximately 300 cubic meters (10,000 cubic feet).

disposal categories represent substantial inventories that could, when combined with the repository inventory, potentially result in increased cumulative impacts.

8.3.2.1.1 *Underground Nuclear Testing*

The United States began a moratorium on the explosive testing of nuclear weapons in October 1992. As discussed in the Nevada Test Site EIS (DIRS 101811-DOE 1996), however, other weapons testing continues at the Test Site, including dynamic, hydrodynamic, and explosive tests. These tests are necessary for the continued assurance of the nuclear arsenal but do not result in nuclear explosions like those that were common during the Cold War. Environmental contamination is due largely to past weapons testing and not to the current limited activities at the Test Site. Although there are potential past and present impacts of the explosive testing of nuclear weapons, the long-lived radionuclides that such testing deposited far underground could pose future impacts, which this section evaluates.

As of September 23, 1992, the estimated total radionuclide source term for all tests was about 130 million curies (DIRS 157116-Bowen et al. 2001, Table V, p. 21). Because these radionuclides are either in or close to the water table and therefore subject to dissolution and possible transport by groundwater, they are referred to as the hydrologic source term. This source term represents the remaining radioisotopes (as of September 23, 1992) that could be available to the groundwater regime. However, because of the existence of multiple, complex migration pathways and limited characterization data, there is considerable uncertainty concerning the actual hydrologic source term. In recent years, the drilling of new characterization wells and the retrofitting of existing boreholes and wells have provided valuable new data that are now being integrated into the overall database so new evaluations can be made. These studies and planned future studies will help reduce the current levels of uncertainty concerning the quantity of radionuclides available for groundwater transport as well as uncertainty concerning both the mechanisms and consequences of radionuclide transport by groundwater flow at the Nevada Test Site. Testing with subcritical assemblies since 1994 has added quantities of material that are very small compared to the historical testing. Thus, the Department has based its analysis on the much larger inventory from historical testing (DIRS 156758-Crowe 2001, all).

There is recent evidence of plutonium migration from one underground test. Groundwater monitoring results indicate that plutonium has migrated about 1.3 kilometers (0.8 mile), possibly facilitated by the movement of very small and relatively mobile particles called *colloids* in the groundwater (DIRS 103282-Kersting et al. 1999, p. 59). No radioactive contamination attributable to underground tests has been detected in monitoring wells off the Nevada Test Site. DOE is conducting further monitoring and research to study these and other potential radionuclide migration phenomenon.

The above information indicates that groundwater could transport radionuclides from underground nuclear tests at the Nevada Test Site. This transport could result in releases from underground testing at the sites analyzed for releases from the proposed repository. DOE did not make long-term performance assessment calculations for the underground testing inventory with the same rigor as the analyses for the repository, and there is much uncertainty related to the hydrogeologic system. Since issuing the Draft EIS, DOE has continued to evaluate design features and operating modes that would reduce uncertainties in or improve long-term repository performance, including the waste package design, and improve operational safety and efficiency. The result of the design evolution process was the development of the Science and Engineering Report flexible design (DIRS 153849-DOE 2001, all). In addition, DOE has continued technical development of the Total System Performance Assessment since the publication of the Draft EIS, including further site characterization, improvements to the engineered system design, system performance assessment calculations, and quality assurance and validation of results. These efforts have resulted in an updated performance assessment referred to as the Total System Performance Assessment-Site Recommendation (TSPA-Site Recommendation; DIRS 153246-CRWMS M&O 2000). The results of this analysis for long-term impacts from the Yucca Mountain Repository are reported in Chapter 5 of this Final EIS. The TSPA-Site Recommendation evaluated the long-term performance of the Science and Engineering Report flexible design and included the best available information related to contaminant fate and transport. The results for the groundwater impacts from the repository in this analysis are substantially lower than reported in the Draft EIS. However, an update of this simplified scaling analysis used to estimate the potential cumulative impact from underground testing at the Nevada Test Site was not performed for the Final EIS because the principal factors affecting contaminant fate and transport remained essentially unchanged between the TSPA-Viability Assessment and the TSPA-Site Recommendation. DOE considers the estimates of Nevada Test Site groundwater impacts developed

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using the simplified model conservative and applicable for environmental evaluation. Further, any minor enhancements to these factors incorporated into the TSPA-Site Recommendation would have yielded results for an updated cumulative analysis well within the uncertainty reported for the analysis based on the TSPA-Viability Assessment. Therefore, DOE developed a simplified analysis that uses the TSPA-Viability Assessment (DIRS 101779-DOE 1998, all) repository infiltration and groundwater fate and transport models to scale groundwater impacts that could result from the underground test inventory. The analysis made the following assumptions for this calculation:

- The total 130-million-curie radionuclide inventory from underground testing at the Nevada Test Site would be available for transport. Tritium constitutes about 90 percent of the total underground testing inventory (DIRS 157116-Bowen et al. 2001, Table V, p. 21). However, the short half-life of tritium (about 12.5 years) would mean that radioactive decay would deplete the tritium inventory to insignificant levels in about 200 years, long before any Yucca Mountain releases would occur. Since potential impacts from tritium migration from the Test Site would not overlap repository impacts temporally, they would not be cumulative. Therefore, DOE did not consider them in this analysis.

- The radionuclide inventory available for transport at the repository would be the estimated curie content of the source material that would become wet in the 10,000-year analysis period. The analysis determined this amount by estimating the quantity of source material in the waste packages and cladding that are predicted to fail (*juvenile* and new *failures*) during the analysis period. Assuming that DOE would emplace 10,000 waste packages in the repository, the package failure rates developed in the TSPA-Viability Assessment indicate two waste package failures with 100 percent of contained elements exhibiting failed cladding. Since issuing the Draft EIS, DOE has continued to evaluate design features and operating modes that would reduce uncertainties in or improve long-term repository performance, including the waste package design, and improve operational safety and efficiency. The result of the design evolution process was the development of the Science and Engineering Report flexible design (DIRS 153849-DOE 2001, all). In addition, DOE has continued technical development of the Total System Performance Assessment since publication of the Draft EIS, including further site characterization, improvements to the engineered system design, system performance assessment calculations, and quality assurance and validation of results. These efforts have resulted in an updated performance assessment referred to as the Total System Performance Assessment-Site Recommendation [TSPA-Site Recommendation (DIRS 153246-CRWMS M&O 2000)]. The results of this analysis for long-term impacts from the Yucca Mountain Repository are reported in Chapter 5 of this Final EIS. The TSPA-Site Recommendation evaluated the long-term performance of the updated Science and Engineering Report flexible design and included the best available information related to contaminant fate and transport. The results for the groundwater impacts from the repository in this analysis are substantially lower than reported in the Draft EIS. However, an update of this simplified scaling analysis used to estimate the potential cumulative impact from underground testing at the Nevada Test Site was not performed for the Final EIS because the principal factors affecting contaminant fate and transport remained essentially unchanged between the TSPA-Viability Assessment and the TSPA-Site Recommendation. DOE considers the estimates of Nevada Test Site groundwater impacts developed using the simplified model conservative and applicable for environmental evaluation. Further, any minor enhancements to these factors incorporated into the TSPA-Site Recommendation would have yielded results for an updated cumulative analysis well within the uncertainty reported for the analysis based on the TSPA-Viability Assessment.

- The estimated total inventory for all underground tests at the Nevada Test Site was 130 million curies as of September 23, 1992 (DIRS 157116-Bowen et al. 2001, Table V, p. 21). As discussed above, the contribution to the total inventory from subcritical experiments is very small and is adequately accounted for by analyzing the inventory from historical testing (DIRS 156758-Crowe 2001, all). The Department only evaluated the radionuclides of interest (that is, those that result in 99 percent of

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the impact; technetium-99, iodine-129, and carbon-14) in this inventory (see Section 5.4.1 of the Draft EIS for details.)

- The total underground testing inventory available for transport would migrate through the same locations as those considered in this EIS for dose calculations for releases from the repository. This is very conservative because much of the water migrating from the underground test locations would discharge to locations other than those for releases from the proposed repository. Such locations include Oasis Valley, Ash Meadows, or the Amargosa Desert.

- The radionuclide-specific distribution coefficients, k_d, are assumed to be equal for source materials at the repository and the Nevada Test Site. This assumption recognizes that most of the nonvolatile radionuclide inventory at the Test Site is captured within the glass-like material resulting from the intense heat generated by past underground tests. The analysis assumed that the leachability of this material is not remarkably different than that of ceramic spent nuclear fuel pellets. Concentrations of the contaminants (curies per milliliter) in leachates are directly proportional to the source material (curies per gram) and the radionuclide-specific distribution coefficients.

- All contaminants originating on the Nevada Test Site would flow to the same discharge points as contaminants from Yucca Mountain, as modeled by the TSPA-Viability Assessment, and the peak groundwater concentrations of contaminants from the Test Site would coincide (in time and space) with the peak groundwater concentrations from repository contaminants.

- Concentrations of radionuclides in the groundwater would be diluted by total infiltration through the repository footprint and groundwater recharge for the repository and the Nevada Test Site, respectively.

The absolute potential cumulative Nevada Test Site groundwater impact can be estimated by comparison with the 10,000-year impacts presented in Table 5-4 of the Draft EIS. Based on these tables, the estimated cumulative Test Site impacts for the Proposed Action for the maximally exposed individual would be about 0.007 millirem per year at 20 kilometers. The dose to the RMEI at 18 kilometers, as described in Chapter 5, would be slightly higher. Therefore, the estimated total potential cumulative impact (Yucca Mountain impact plus Nevada Test Site impact) would be essentially (because of the small contribution from the proposed repository) 0.007 millirem per year to the RMEI.

Because of the large uncertainties in the current level of understanding of the hydrogeologic system, DOE has not attempted to model the actual groundwater transport of the Nevada Test Site with this simplified model. However, by assuming that the radionuclide contaminants in the groundwater at the Test Site would be transported in an identical manner to those from the repository and that peak concentrations would occur at precisely the same time, the Department believes that the resulting estimates of cumulative impacts from underground testing activities represent a reasonable upper bound of the actual cumulative impacts.

Uncertainties associated with Nevada Test Site groundwater impacts:

- *Source material concentration* – The concentration of contaminants within the source material is the parameter with the most sensitivity to outcome but also the parameter that the least is known about at the Nevada Test Site. However, the actual Test Site concentrations could be higher than those estimated for this analysis and still have little effect on the outcome. This is because, as the density of the Test Site inventory increases (that is, the radionuclide inventory is assumed to occupy a smaller volume), the quantity of infiltration “seen” by the contaminant would decrease because of the reduced footprint of the source term. Since both of these terms (radionuclide density and water infiltration per unit area) are directly proportional to the calculated groundwater concentration, they would tend to offset one another. However, for conservatism, the assumption was made that all of the Test Site source term for radionuclides of interest was concentrated only in the affected soil at Yucca Flat. This assumption could have resulted in an overestimate of the Test Site concentration and potential impacts by as much as two.

- *Travel distances and times* – The conservative assumption was made that the contaminants from Yucca Mountain and the Nevada Test Site would travel along the same pathways (those assumed for Yucca Mountain in the TSPA-Viability Assessment) and at the same time to maximize potential impacts. If more realistic modeling had been performed, the peak contaminate concentrations from Yucca Mountain and the Test Site probably would not coincide and the Test Site contribution to the cumulative impacts would therefore be smaller than those estimated.

- *Solute partition coefficients* – These coefficients as described in the literature are known to vary by orders of magnitude depending on soil and source zone material types. Because the precise nature of the soils at the Nevada Test Site was not considered in the simplified analysis, the actual result could be different. However, these values are not readily available and are impossible to estimate accurately with currently available data.

- *Contaminant mobilization* – To simplify the analysis, the assumption was made that the waste isolated in engineered barrier systems for the Yucca Mountain Repository and the waste dispersed in glass-like material from underground nuclear blasts at the Nevada Test Site will have the same release characteristics. The actual mechanisms for waste mobilization for Test Site underground testing contamination are largely unknown. The actual differences in the mobilization of the contaminants could result in changes (larger or smaller) in the impact estimates, however, due to the relative size of the calculated impacts, coupled with the other conservatisms assumed in this simplified analysis, they are not likely to influence the conclusion.

- *Groundwater flow direction and discharge points* – If realistic modeling was performed, and adequate characterization data to support that modeling was available, then it is extremely unlikely that the modeling would show that all contaminants resulting from underground testing across the Nevada Test Site would migrate to only one discharge point and that point would be the same point of discharge as the releases from the Yucca Mountain Repository. More detailed information on actual groundwater flow would likely serve to reduce the estimated impact of the Test Site inventory.

8.3.2.1.2 *Greater Confinement Disposal*

Waste disposed of at the Nevada Test Site under Greater Confinement Disposal constitutes a radiological source term that is less than 10 percent of the repository radionuclide source term immediately available for groundwater transport when the first waste packages at the Yucca Mountain Repository are assumed to have initially degraded (that is, 2 percent of the total repository radionuclide source term). The waste disposed of by Greater Confinement Disposal was placed in boreholes that are approximately 37 meters (120 feet) deep; the waste itself is no closer than approximately 21 meters (70 feet) to the surface. DOE has reviewed analyses related to the Nevada Test Site and has concluded that there is no credible pathway for long-term releases of materials by resuspension of nonvolatile radionuclides because the material is sufficiently far below the surface. In addition, evapotranspiration exceeds precipitation in this region, which, coupled with the fact that the boreholes are sufficiently above the water table (more than 125 meters), indicates that there is no credible release scenario for Greater Confinement Disposal material to enter the groundwater. Therefore, DOE expects no cumulative impacts from Greater Confinement Disposal activities.

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8.3.2.1.3 *Future Nevada Test Site Low-Level Waste Disposal*

The Nevada Test Site is a disposal site for low-level radioactive waste generated by DOE-approved generators. Managed radioactive waste disposal operations began in the early 1960s, and DOE has disposed of low-level, transuranic, mixed, and classified low-level wastes in selected pits, trenches, landfills, and boreholes on the Nevada Test Site. Environmental impacts from the disposal of low-level waste at the Nevada Test Site are discussed in the Nevada Test Site Final EIS (DIRS 101811-DOE 1996, pp. 2-15 to 2-17). The current source term of low-level and mixed wastes in shallow land disposal on the Nevada Test Site does not constitute a substantial inventory in relation to the radionuclide source term immediately available for groundwater transport from the repository when the first waste packages initially degrade (that is, 2 percent of the total repository radionuclide source term). However, shallow burial of low-level radioactive waste continues to be an important waste disposal activity at the Nevada Test Site. Therefore, this section evaluates reasonably foreseeable future activities in this category as a potential cumulative impact.

Waste disposal activities on the Nevada Test Site occur at two specific locations. They are the Area 3 and Area 5 Radioactive Waste Management Sites. The Area 3 Radioactive Waste Management Site is on Yucca Flat and covers an area of approximately 0.2 square kilometer (50 acres). DOE uses conventional landfill techniques to dispose of contaminated debris from the Nevada Test Site Atmospheric Testing Debris Disposal Program and packaged bulk low-level waste from other DOE sites in subsidence craters from underground nuclear tests. The estimated total remaining capacity for low-level waste in the Area 3 site is 1.8 million cubic meters (64 million cubic feet) (DIRS 103224-DOE 1998, Section A.5.2) .

DOE has used the Area 5 Radioactive Waste Management Site since 1961 to dispose of low-level waste and classified low-level waste from Nevada Test Site operations. In 1978, the Test Site began accepting low-level waste generated by other DOE sites. The total area of the Area 5 site is 3 square kilometers (740 acres). The developed portion occupies 0.37 square kilometer (92 acres) in the southeast corner and contains 17 landfill cells (pits and trenches), 13 Greater Confinement Disposal boreholes, and a transuranic waste storage pad. DOE is seeking a Resource Conservation and Recovery Act permit for Pit 3 as a mixed-waste disposal unit. In the future, if the mixed-waste volume warranted it, the Department might consider obtaining a new unit and, hence, a new permitted facility. However, current projected waste volumes do not indicate the need for an additional mixed-waste disposal unit at this time. The estimated total remaining capacity for low-level waste in the Area 5 Radioactive Waste Management Site is 1.2 million cubic meters (42 million cubic feet) (DIRS 103224-DOE 1998, Section A.5.3).

As discussed in Section 8.2.12.1, DOE projects a need for 1.1 million cubic meters of capacity for low-level waste disposal at the Nevada Test Site through 2070 (DIRS 155856-DOE 2000, Table 4-1).

The Final Waste Management Programmatic EIS (DIRS 101816-DOE 1997, Summary) reported volumes of radioactive waste DOE may dispose of at the Nevada Test Site for “current plus 20 years” of waste disposal. The current inventory plus 20 years of additional disposal inventory would total 3,000 cubic meters (106,000 cubic feet) of low-level mixed waste, 1,700 cubic meters (60,000 cubic feet) of low-level waste, and 610 cubic meters (21,500 cubic feet) of transuranic waste (DIRS 101816-DOE 1997, Summary, p. 102). The Nevada Test Site Final EIS (DIRS 101811-DOE 1996, Table 4-1, p. 4-6) estimates the total current inventory already in shallow disposal at the Nevada Test Site to be 500,000 curies at the time of disposal (uncorrected for decay to the present time).

According to the Final Waste Management Programmatic EIS, the only expected groundwater impacts from low-level mixed, low-level radioactive, and transuranic waste disposal at the Nevada Test Site in excess of regulatory limits are for the hazardous chemicals 1,2-dichloroethane, methylene chloride, and benzene, and those only under Regionalized Alternative 3 and the Preferred Alternative in that EIS (DIRS 101816-DOE 1997, p. 11-61). None of these hazardous chemicals would be in the Yucca Mountain

Repository inventory, so there would be no potential cumulative impacts from those chemicals from the Proposed Action or Inventory Module 1 or 2.

DOE has estimated potential long-term impacts from radioactive material disposed of at the Nevada Test Site. DOE based its calculations of long-term atmospheric releases for the Nevada Test Site on estimates of the inventory at the Test Site that could be accessible by residents around the area. For this calculation, the Department considered three potential sources of radionuclide releases:

- The Area 3 radioactive waste disposal area
- The Area 5 radioactive waste disposal area
- Soil sites around the Nevada Test Site that are contaminated at or near the surface from nuclear weapons testing

Because this material is not near the water table and because evapotranspiration exceeds precipitation in this area, there is no credible release scenario for this material to enter the groundwater. DOE postulated that, over time, weathering at the site could resuspend contaminants in the air and transport them from the contaminated areas to offsite residents. Therefore, DOE performed calculations using current meteorological information for the Nevada Test Site and site-specific resuspension factors to estimate the amount of material that could be released off the site. To ensure conservatism in the estimate, DOE assumed that the three sources listed above were in the same location (even though in reality they are separated by large distances) and that a future resident could be as near as 100 meters (330 feet) from the site. Analyses based on these assumptions are likely to overestimate the true impacts to a future resident because they result in a calculated total emission and radiation dose that is probably higher than if a resident were within 100 meters of a single site.

Based on these conservative assumptions, DOE calculated that the total radiation dose from the three sources could be approximately 7 millirem for each year of exposure during the first 10,000 years, and DOE does not expect that the dose would increase beyond that value for as long as 1,000,000 years. If a resident received this dose as long as 70 years, that person's lifetime dose could be as high as 490 millirem, which could result in an increased risk of fatal cancer of 0.0002.

8.3.2.2 Past Actions and Present Actions at the Beatty Low-Level Radioactive Waste Disposal and Hazardous Waste Treatment Storage and Disposal Facilities

A low-level radioactive waste disposal facility, formerly operated by U.S. Ecology, a subsidiary of American Ecology, is 16 kilometers (10 miles) southeast of Beatty, Nevada, and 180 kilometers (110 miles) northwest of Las Vegas. This site is about 15 kilometers (9.3 miles) west of the proposed Yucca Mountain Repository (see Figure 8-2). The disposal facility, which opened in 1962, covers roughly 0.14 square kilometer (35 acres) of unlined trenches. Acceptance of low-level radioactive waste ended December 31, 1992 (DIRS 101815-DOE 1997, Chapter 4, Table 4-17). The Nevada State Health Division formally accepted permanent custody of the low-level radioactive commercial waste disposal in a letter to American Ecology dated December 30, 1997 (DIRS 148088-AEC 1998, all). An adjacent U.S. Ecology facility remains open for hazardous waste disposal.

From 1962 through 1992, the inventory shipped to the Beatty low-level radioactive waste facility totaled 137,000 cubic meters (4.8 million cubic feet) in volume (DIRS 101815-DOE 1997, Chapter 4, Table 4-17) with radioactivity of about 640,000 curies (DIRS 101815-DOE 1997, Chapter 4, Table 4-18). The radioactivity in this sum was measured by year of shipment (that is, it is not corrected for decay since that time).

The Manifest Information Management System (DIRS 148160-MIMS 1992, all) calculated the total radionuclide inventory the Beatty facility received from 1986 through 1992, which represents 29 percent of the total undecayed inventory at that facility. Even if multiplied by a factor of 3 to 4 to compensate for the period (1962 to 1985) for which the Manifest Information Management System did not provide information, the source term represents a small percentage of the radionuclide source term immediately available for groundwater transport from the repository when the first waste packages initially degrade (that is, 2 percent of the total repository radionuclide source term). Therefore, cumulative long-term impacts from the Beatty Low-Level Radioactive Waste Disposal Facility with the repository would be very small.

The U.S. Ecology Hazardous Waste Treatment, Storage and Disposal Facility is a Resource Conservation and Recovery Act-permitted facility, with engineered barriers and systems and administrative controls that minimize the potential for offsite migration of hazardous constituents.

8.4 Cumulative Transportation Impacts

This section discusses the results of the cumulative impact analysis of transportation. Paralleling the transportation analyses of the Proposed Action in Chapter 6, potential national transportation cumulative impacts from Inventory Module 1 or 2, and past, present, and reasonably foreseeable future actions, are presented in Section 8.4.1. Potential cumulative impacts with construction and operation of the Nevada transportation implementing rail and heavy-haul truck alternatives are included in Section 8.4.2.

The shipment of Inventory Module 1 or 2 to the repository would use the same transportation routes, but would take more shipments and an additional 14 years compared to the Proposed Action. Table 8-2 lists the estimated number of shipments for Modules 1 and 2. Impacts from Module 1 or 2 would be similar because the shipping rate would be the same for spent nuclear fuel and high-level radioactive waste and only about 3 percent more shipments would be made over the 38-year period under Module 2 to transport Greater-Than-Class-C and Special-Performance-Assessment-Required wastes. Because the difference in impacts between Inventory Modules 1 and 2 would be small, the following discussions present the impacts from both modules as being the same.

8.4.1 NATIONAL TRANSPORTATION

This section describes cumulative impacts from national transportation. Section 8.4.1.1 presents potential cumulative impacts from shipping Inventory Module 1 or 2 from commercial nuclear generating sites and DOE facilities to the proposed Yucca Mountain Repository (Section 8.4.1.1). Section 8.4.1.2 presents potential cumulative national transportation impacts for the Proposed Action and Module 1 or 2 when combined with past, present, and reasonably foreseeable future shipments of radioactive material.

8.4.1.1 Inventory Module 1 or 2 Impacts

This section describes the potential cumulative impacts of loading operations at generating sites and incident-free radiological impacts, vehicle emission impacts, and accident impacts associated with transportation activities for Inventory Module 1 or 2. Cumulative impact results are provided for the mostly legal-weight truck and mostly rail scenarios which are described in Chapter 6. The section also describes potential cumulative impacts from transportation of other materials, personnel, and repository-generated waste for Modules 1 or 2. Appendix J contains additional detailed analysis results.

Loading operations would be extended for an additional 14 years to load the greater quantities of spent nuclear fuel and high-level radioactive waste under Inventory Module 1 or 2. The impacts of routine loading operations described for the Proposed Action in Chapter 6, Section 6.2.2, would increase for Module 1 or 2 due to the additional inventory. Therefore, the increase in dose to the public would be

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about 42 person-rem based on 0.001 person-rem per metric ton of heavy metal and 42,000 additional MTHM (46,000 tons) (DIRS 104731-DOE 1986, Volume 2, p. E.6) for Modules 1 and 2. This dose could result in an additional 0.02 cancer fatality in the exposed population. Table 8-54 lists estimated radiological and industrial hazard impacts to involved workers for the routine loading operations under Module 1 or 2. The Proposed Action impacts are listed for comparison.

Table 8-54. Radiological and industrial hazard impacts to involved workers from loading operations.[a,b]

Impact	Proposed Action[b]		Inventory Module 1 or 2	
	Mostly legal-weight truck scenario	Mostly rail scenario	Mostly legal-weight truck scenario	Mostly rail scenario
Radiological				
Maximally exposed individual				
Dose (rem)[c]	12	12	12	12
Probability of latent cancer fatalities	0.005	0.005	0.005	0.005
Involved worker population				
Dose (person-rem)	15,000	4,200	32,000	8,400
Number of latent cancer fatalities	6.0	1.7	13	3.4
Industrial hazards				
Total recordable cases[d]	380	130	770	260
Lost workday cases[e]	200	70	400	130
Fatalities[f]	0.88	0.3	1.8	0.6

a. Includes all involved workers at all facilities and does not vary by operating mode.
b. Source: Chapter 6, Section 6.2.
c. Assumes 500 millirem per year to radiation workers. The average individual exposure was assumed to be 24 years for both the Proposed Action and Inventory Module 1 or 2 since 24 years is a conservatively long time to assume an individual would be involved in loading operations.
d. Total recordable cases based on a loss incidence rate of 0.084.
e. Lost workday cases based on a loss incidence rate of 0.046.
f. Fatalities based on a loss incidence rate of 0.000218.

Because noninvolved workers would not have tasks that involved radioactive exposure, there would be no or very small radiological impacts to noninvolved workers. For the reasons identified in Chapter 6, Section 6.2.2.2, industrial hazard impacts to noninvolved workers would be about 25 percent of the impacts to the individual worker shown in Table 8-54.

The impacts of loading accident scenarios under Inventory Module 1 or 2 would be the same as those described for the Proposed Action in Chapter 6, Section 6.2.4.1. The same type of single accident event and its impacts are applicable to shipments under the Proposed Action or Module 1 or 2. As summarized in Chapter 6, Section 6.2.4.1, the analysis results indicate that there would be no or very small potential radiological consequences from loading accident scenarios involving spent nuclear fuel or high-level radioactive waste. These consequences would bound the consequences from similar accidents involving Greater-Than-Class-C or Special-Performance-Assessment-Required waste because of the lower available radionuclide inventory (see Appendix A).

Table 8-55 lists radiological impacts to involved workers and the public and vehicle emission impacts from incident-free transportation for the mostly legal-weight truck and mostly rail scenarios. The analysis of impacts for the mostly legal-weight truck scenario assumed that shipments would use commercial motor carriers for highway transportation and general freight commercial services for rail transportation for the naval spent fuel shipments that cannot be transported by legal-weight trucks. The mostly rail analysis accounts for legal-weight truck shipments that would occur for the commercial nuclear generator sites that do not currently have the capacity to handle or load rail casks. In addition, for the mostly rail analysis, DOE assumed that it would use either a branch rail line or heavy-haul trucks in conjunction with an intermodal transfer station in Nevada to transport the large rail casks to and from the

Table 8-55. Radiological and vehicle emission impacts from incident-free national transportation.

Category	Proposed Action[a,b] Mostly legal-weight truck scenario[d]	Proposed Action[a,b] Mostly rail scenario[e]	Inventory Module 1 or 2[c] Mostly legal-weight truck scenario[d]	Inventory Module 1 or 2[c] Mostly rail scenario[e]
Involved worker				
Collective dose (person-rem)	14,000	3,700 - 4,600	28,000	7,100 - 8,800
Estimated number of latent cancer fatalities	5.6	1.5 - 1.9	11.2	2.8 - 3.5
Public				
Collective dose (person-rem)	5,000	1,200 - 1,600	9,700	2,200 - 3,100
Estimated number of latent cancer fatalities	2.5	0.6 - 0.82	5.0	1.1 - 1.6
Estimated vehicle emission-related fatalities	0.95	0.5 - 0.8	1.9	0.9 - 1.4

a. Source: Chapter 6, Section 6.2.3.
b. Impacts are totals for shipments over 24 years.
c. Impacts are totals for shipments over 38 years.
d. Includes rail shipments of naval spent nuclear fuel to Nevada, and intermodal transfer station and heavy-haul truck operations for this fuel in Nevada.
e. Includes legal-weight truck shipments from commercial nuclear generator sites that do not have the capacity to handle or load rail casks, and the rail and heavy-haul truck implementing alternatives for Nevada described in Chapter 6.

repository. The range provided in the table for the mostly rail scenario addresses the different possible rail and heavy-haul truck implementing alternatives described in Chapter 6. The lower end of the range reflects use of a branch rail line in Nevada and the upper end of the range reflects use of heavy-haul trucks in Nevada. The involved worker impacts in Table 8-55 include estimated radiological exposures of truck and rail transportation crews and security escorts for legal-weight truck and rail shipments; the public doses account for the public along the route, the public sharing the route, and the public during stops. The Inventory Module 1 or 2 impacts would exceed those of the Proposed Action due to the additional number of shipments.

DOE does not expect radiological impacts for maximally exposed individuals to change from the Proposed Action due to the conservative assumptions used in the analysis of the Proposed Action (see Chapter 6, Section 6.2.3). The assumptions for estimating radiological dose include the use of the maximum allowed dose rate and conservative estimates of exposure distance and time. For example, the U.S. Department of Transportation maximum allowable dose rate of 10 millirem per hour at a distance of 2 meters (6.6 feet) [40 CFR 173.44(b)] was used for estimating exposure to individuals. In addition, the conservative assumptions for exposure distance and time for workers (that is, crew members, inspectors, railyard crew member) and the public (that is, resident along route, person in a traffic jam, person at a service station, resident near a rail stop) for the Proposed Action are unlikely to be exceeded for Inventory Module 1 or 2 (see Chapter 6, Section 6.2.3).

Table 8-56 lists the radiological accident risk and traffic fatalities for transportation by mostly legal-weight truck and mostly rail for Inventory Module 1 or 2. The radiological accident risk measures the total impact of transportation accidents over the entire shipping campaign (24 years for the Proposed Action and 38 years for Module 1 or 2). The consequences from a maximum reasonably foreseeable accident scenario would be identical to those discussed for the Proposed Action (see Chapter 6, Sections 6.2.4.2.1 and 6.2.4.2.2) because the parameters and conditions for the hypothetical accident event involving spent nuclear fuel or high-level radioactive waste would be the same for a shipment under the Proposed Action or Module 1 or 2. In addition, the hypothetical accident would be bounding for accident scenarios involving Greater-Than-Class-C and Special-Performance-Assessment-Required wastes.

As summarized in Chapter 6, Section 6.1.3, and further described in Appendix J, in addition to the transportation of spent nuclear fuel and high-level radioactive waste to the repository, other materials

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Table 8-56. Accident risk for mostly legal-weight truck and mostly rail scenarios.

Category	Proposed Action[a]		Inventory Module 1 or 2	
	Mostly legal-weight truck scenario	Mostly rail scenario	Mostly legal-weight truck scenario	Mostly rail scenario
Radiological accident risk				
Collective dose risk (person-rem)	0.46	0.8 - 1.0	0.87	1.3 - 1.6
Estimated number of latent cancer fatalities	0.00023	0.00041 - 0.00050	0.00043	0.00066 - 0.00080
Traffic accident fatalities	4.9	2.3 - 3.1	8.7	4.2 - 5.9

a. Source: Chapter 6, Section 6.2.4.2.

would require transportation to and from the proposed repository. These materials would include construction materials, consumables, repository components (disposal containers, drip shields, etc.), office and laboratory supplies, mail, and laboratory samples. Required transportation would also include personnel commuting to the Yucca Mountain site and the shipment of repository-generated wastes offsite for treatment, storage, or disposal.

The implementation of Inventory Module 1 or 2 would increase this transportation as a result of the additional required subsurface development and the longer time required for repository development, emplacement, and closure. However, even with the increased transportation of other material, personnel, and repository-generated wastes for Module 1 or 2, DOE would expect these transportation impacts to be small contributors to the total transportation impacts on a local, state, and national level with no large cumulative impacts based on the analysis of the Proposed Action in Section 6.1.3. The annual air quality impacts for Inventory Module 1 or 2 would be the same as those conservatively estimated in Section 6.1.3 and, therefore, no cumulative air quality impacts would be expected in the Las Vegas airshed, which is in nonattainment for carbon monoxide. Table 8-57 summarizes fatalities from transporting other materials, personnel, and repository-generated waste. The estimated fatalities assume truck shipments in Nevada which would have higher potential impacts than shipments by rail. The Proposed Action impacts are listed in the table for comparison.

Table 8-57. Impacts from transportation of materials, consumables, personnel, and waste.[a,b]

Category	Proposed Action		Inventory Module 1 or 2	
	Kilometers traveled[c]	Fatalities	Kilometers traveled (Module 1/Module 2)	Fatalities (Module l/Module 2)
Materials (including repository components)	130,000,000 - 270,000,000	4.1 - 7.8	170,000,000 - 310,000,000	5.6 - 9.8
Personnel	480,000,000 - 800,000,000	5.4 - 9.2	640,000,000 - 930,000,000	7.3 - 11
Repository-generated waste				
Hazardous	57,000 - 71,000	0.001 - 0.002	110,000 - 170,000	0.002 - 0.003
Low-level radioactive	230,000 - 320,000	0.004 - 0.006	430,000 - 1,000,000	0.008 - 0.02
Nonhazardous solid	5,600,000 - 10,400,000	0.1 - 0.2	7,000,000 - 9,500,000	0.13 - 0.18
Totals	***610,000,000 - 1,100,000,000***	***9.6 - 17***	***820,000,000 - 1,300,000,000***	***13 - 20***

a. Totals might differ from sums of values due to rounding.
b. Source: Appendix J, Section J.3.6.
c. To convert kilometers to miles, multiply by 0.62137.

8.4.1.2 Cumulative Impacts from the Proposed Action, Inventory Module 1 or 2, and Other Federal, Non-Federal, and Private Actions

The overall assessment of cumulative national transportation impacts for past, present, and reasonably foreseeable future actions concentrated on the cumulative impacts of offsite transportation, which would yield potential radiation doses to a greater portion of the general population than onsite transportation and would result in fatalities from traffic accidents. The collective dose to workers and to the general population was used to quantify overall cumulative radiological transportation impacts. This measure was chosen because it could be related directly to latent cancer fatalities using a cancer risk coefficient and because of the difficulty in identifying a maximally exposed individual for shipments throughout the United States from 1943 through 2047. Operations at the Hanford Site and the Oak Ridge Reservation began in 1943, and 2047 is when the EIS analysis assumed that radioactive material shipments to the repository for Inventory Module 1 or 2 would end. The source of this cumulative transportation impacts analysis is the Yucca Mountain EIS Environmental Baseline File on transportation (DIRS 104800-CRWMS M&O 1999, Section 7.0), with the exception of impacts from the Proposed Action and Module 1 or 2, which are from Table 8-55.

The cumulative impacts of the transportation of radioactive material would consist of impacts from:

- Historic DOE shipments of radioactive material associated with the Nevada Test Site, the Idaho National Engineering and Environmental Laboratory, the Savannah River Site, the Hanford Site, the Oak Ridge Reservation, and naval spent nuclear fuel and test specimens

- Reasonably foreseeable actions that include the transportation of radioactive material identified in DOE Environmental Policy Act analyses; for example, the Nevada Test Site Environmental Impact Statement (DIRS 101811-DOE 1996, all), the Department of Energy Spent Nuclear Fuel Management Environmental Impact Statement (DIRS 101802-DOE 1995, all; DIRS 101812-DOE 1996, all), and the Final Department of Energy Waste Management Environmental Impact Statement (DIRS 101816-DOE 1997, all) (see Table 8-58). In some cases, transportation impacts included impacts that may have been double counted. For example, the transportation impacts from shipping 40,000 MTHM of spent nuclear fuel to a potential Private Fuel Storage Facility in Tooele County, Utah (DIRS 152001-NRC 2000, all) were included in Table 8-58, but the transportation impacts from the Proposed Action were not decreased to account for this 40,000 MTHM. Table 8-58 also includes reasonably foreseeable projects that include limited transportation of radioactive material (for example, shipment of submarine reactor components from the Puget Sound Naval Shipyard to the Hanford Site for burial, and shipments of uranium billets and low-specific-activity nitric acid from the Hanford Site to the United Kingdom). In addition, for reasonably foreseeable future actions where a preferred alternative was not identified or a Record of Decision has not been issued, the analysis used the alternative estimated to result in the largest transportation impacts. While this is not an exhaustive list of the projects that could include limited transportation of radioactive material, it indicates that the transportation impacts associated with such projects are low in comparison to major projects or general transportation.

- General radioactive materials transportation that is not related to a particular action; for example, shipments of radiopharmaceuticals to nuclear medicine laboratories and shipments of commercial low-level radioactive waste to commercial disposal facilities

- Shipments of spent nuclear fuel, high-level radioactive waste, Greater-Than-Class-C waste, and Special-Performance-Assessment-Required waste under the Proposed Action or Inventory Module 1 or 2

Table 8-58 summarizes the worker and general population doses from the transport of radioactive material. The estimated total cumulative transportation-related collective worker doses from the mostly legal-weight truck shipments (past, present, and reasonably foreseeable actions) with the Proposed Action would be about 360,000 person-rem (140 latent cancer fatalities), and with Inventory Module 1 or 2 about 410,000 person-rem (160 latent cancer fatalities). The estimated total general population doses for the mostly legal-weight truck shipments would be about 320,000 person-rem (160 latent cancer fatalities) with the Proposed Action, and about 350,000 person-rem (180 latent cancer fatalities) with Module 1 or 2. Most of the dose for workers and the general population would be due to general transportation of radioactive material. The estimated total cumulative number (workers plus population) of latent cancer fatalities with the Proposed Action would be about 300, and about 340 with Module 1 or 2. To place

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Table 8-58. Cumulative transportation-related radiological doses, latent cancer fatalities, and traffic fatalities.[a]

Category	Worker dose (person-rem)	General population dose (person-rem)	Traffic fatalities
Historical DOE shipments (DIRS 101811-DOE 1996, all)	330	230	NL[b]
Reasonably foreseeable actions			
Private Fuel Storage Facility (DIRS 152001-NRC 2000, all)	29	190	0.78
Sodium-Bonded Spent Nuclear Fuel (DIRS 157167-DOE 2000, all)	0.0044	0.032	0.0001
Idaho High-Level Waste and Facilities (DIRS 155100-DOE 1999, all)	530	2,900	0.1
Surplus Plutonium Disposition (DIRS 118979-DOE 1999, all)	60	67	0.053
Sandia National Laboratories Site-Wide EIS (DIRS 157155-DOE 1999, all)	94	590	1.3
Depleted Uranium Hexafluoride (DIRS 152493-DOE 1999, all)	--[c]	750	4
Tritium Production in a Commercial Light Water Reactor (DIRS 157166-DOE 1999, all)	16	80	0.06
Parallex Project (DIRS 157153-DOE 1999, all)	0.00001	0.00007	0.00005
Los Alamos National Laboratory Site-Wide EIS (DIRS 157154-DOE 1999, all)	580	310	8
Plutonium Residues at Rocky Flats (DIRS 155932-DOE 1998, all)	2.1	1.3	0.0078
Import of Russian Plutonium-238 (DIRS 157156-DOE 1993, all)	1.8	4.4	0.0036
Nevada Test Site expanded use (DIRS 101811-DOE 1996, all)	--	150[d]	8
Spent nuclear fuel management (DIRS 101802-DOE 1995, all; DIRS 101812-DOE 1996, all)	360	810	0.77
Waste Management PEIS (DIRS 101816-DOE 1997, all)[e]	16,000	20,000	36
Waste Isolation Pilot Plant (DIRS 101814-DOE 1997, all)	790	5,900	5
Molybdenum-99 production (DIRS 101813-DOE 1996, all)	240	520	0.1
Tritium supply and recycling (DIRS 103208-DOE 1995, all)	--	--	0.029
Surplus HEU disposition (DIRS 103216-DOE 1996, all)	400	520	1.1
Storage and Disposition of Fissile Materials (DIRS 103215-DOE 1996, all)	--	2,400[d]	5.5
Stockpile Stewardship (DIRS 103217-DOE 1996, all)	--	38[d]	0.064
Pantex (DIRS 103218-DOE 1996, all)	250[f]	490[d]	0.006
West Valley (DIRS 101729-DOE 1996, all)	1,400	12,000	3.6
S3G and D1G prototype reactor plant disposal (DIRS 103221-DOE 1997, all)	2.9	2.2	0.010
S1C prototype reactor plant disposal (DIRS 103219-DOE 1996, all)	6.7	1.9	0.0037
Container system for Naval spent nuclear fuel (DIRS 101941-USN 1996, all)	11	15	0.045
Cruiser and submarine reactor plant disposal (DIRS 103479-USN 1996, all)	5.8	5.8	0.00095
Submarine reactor compartment disposal (DIRS 103477-USN 1984, all)	--	0.053	NL
Uranium billets (DIRS 103189-DOE 1992, all)	0.50	0.014	0.00056
Nitric acid (DIRS 103212-DOE 1995, all)	0.43	3.1	NL
General radioactive material transportation			
1943 to 2033	310,000	260,000	19
1943 to 2047	330,000	290,000	22
Subtotal of non-repository-related transportation impacts			
1943 to 2033	**330,000**	**310,000**	**94**
1943 to 2047	**350,000**	**340,000**	**97**
Proposed Action			
Mostly legal-weight truck	29,000	5,000	4.5
Mostly rail	7,900 - 8,800	1,200 - 1,600	2.3 - 3.1
Module 1 or 2[g]			
Mostly legal-weight truck	60,000	9,700	8.7
Mostly rail	16,000 - 17,000	2,200 - 3,100	4.2 - 5.9
Total collective dose (total latent cancer fatalities)[h] *and total traffic fatalities*			
Proposed Action			
Mostly legal-weight truck	360,000 (140)	320,000 (160)	98
Mostly rail	340,000 (140)	310,000 (160)	97
Module 1 or 2[g]			
Mostly legal-weight truck	410,000 (160)	350,000 (180)	110
Mostly rail	370,000 (150)	340,000 (170)	100

a. Sources: DIRS 104800-CRWMS M&O (1999, Section 7) except for the Proposed Action and Inventory Module 1 or 2, which are from Table 8-54. All references in this table refer to the original source of information cited in DIRS 104800-CRWMS M&O (1999, Section 7).
b. NL = not listed.
c. -- = reported or included with the general population dose.
d. Includes worker and general population doses.
e. Includes mixed low-level waste and low-level waste; transuranic waste included in DIRS 101814-DOE (1997, Volume 1).
f. Includes all highly enriched uranium shipped to Y-12.
g. The transportation-related radiological collective doses for Inventory Module 1 or 2 include the doses from the Proposed Action (see the definition of Modules 1 and 2 in Section 8.1.2.1).
h. The conversion factors for worker and general population dose to latent cancer fatalities are 0.0004 and 0.0005 latent cancer fatality per person-rem, respectively (DIRS 101856-NCRP 1993, p. 31) occurred in the United States. Therefore, the number of vehicular accident fatalities was used to quantify the cumulative impacts of transportation accidents.

these numbers in perspective, there were 541,532 deaths in the United States during 1998 due to cancer, although the number for any given year understandably fluctuates (DIRS 153066-Murphy 2000, p. 83). This section presents an estimate of latent cancer fatalities slightly greater than 300 over a period of about 100 years (that is, an average of about 3 latent cancer fatalities per year). This value would be indistinguishable from the natural fluctuations in the death rate from cancer.

For transportation accidents involving radioactive material, the dominant risk is due to accidents that are not related to the cargo (traffic or vehicular accidents). Typically, the radiological accident risk (latent cancer fatalities) from transportation accidents is less than 1 percent of the vehicular accident risk (see Table 8-56). In addition, no acute radiological fatalities due to transportation accidents have ever occurred in the United States. Therefore, the number of vehicular accident fatalities was used to quantify the cumulative impacts of transportation accidents.

From 1943 through 2033 an estimated 4 million people would be killed in motor vehicle accidents and 180,000 people would be killed by railroad accidents. From 1943 through 2047, an estimated 4.4 million people would be killed in motor vehicle accidents and 200,000 people would be killed in railroad accidents. Based on the estimated number of traffic fatalities for the reasonably foreseeable actions and for the Proposed Action and Inventory Module 1 or 2 listed in Table 8-58, the transport of radioactive material would contribute about 110 fatalities to these totals.

8.4.2 NEVADA TRANSPORTATION

This section analyzes potential cumulative impacts that Inventory Module 1 or 2 and past, present, and other reasonably foreseeable future Federal, non-Federal, and private actions could have on the construction and operation of a branch rail line or the construction and operation of an intermodal transfer station and associated highway upgrades for heavy-haul trucks in the State of Nevada. The analysis included potential cumulative impacts in the vicinity of the five potential branch rail line corridors, the three potential intermodal transfer station locations, and the five associated potential highway routes for heavy-haul trucks.

With respect to potential cumulative impacts from Inventory Module 1 or 2, there would be no cumulative construction impacts because the need for a new branch rail line or new intermodal transfer station and associated highway upgrades for heavy-haul trucks would not change; that is, whatever DOE would build for the Proposed Action would also serve Module 1 or 2. In addition, because the planned annual shipment rate of spent nuclear fuel and high-level radioactive waste to the Yucca Mountain Repository would be about the same for Module 1 or 2 and the Proposed Action, the only cumulative operations impacts would result because of the extra 14 years of shipping time required for Module 1 or 2. With this basis, the operation and maintenance of a branch rail line or an intermodal transfer station and associated highway route for heavy-haul trucks were analyzed for potential cumulative impacts from Module 1 or 2.

Land-use and ownership impacts identified in Chapter 6 (Section 6.3) would be avoided or otherwise resolved to implement the Proposed Action. However, additional conflicts associated with continued use of the affected land areas could occur due to shipping operations being excluded 14 years beyond that analyzed in the Proposed Action. DOE expects no cumulative impacts from the extended 14 years of operation for Inventory Module 1 or 2 to air quality; hydrology (surface water and groundwater); biological resources and soils; cultural resources; socioeconomics; noise; aesthetics; and utilities, energy, and materials, the impacts of which were assessed on a per shipment, weekly, or annual basis (see Chapter 6, Section 6.3).

Cumulative impacts from Inventory Module 1 or 2 to occupational and public health and safety are included in the occupational and public health and safety impacts of national transportation in

Section 8.4.1. The operation of an intermodal transfer station for more years under Module 1 or 2 would affect waste management impacts. Because of the additional years of operation, more waste of the same types would be generated than for the Proposed Action. However, the small waste quantities generated for Module 1 or 2 would have a minimal impact to the receiving treatment and disposal facilities. Because there would be no large cumulative impacts for any of the resource areas from Module 1 or 2, disproportionately high and adverse cumulative impacts to minority or low-income populations or to Native Americans would be unlikely.

Other than Inventory Module 1 or 2, one other Federal action and several private actions could have the potential for cumulative impacts with the construction and operation of a new branch rail line or intermodal transfer station and associated highway route for heavy-haul trucks.

One private action that could lead to cumulative impacts with the Carlin rail corridor implementing alternative is by Cortez Gold Mine, Inc., which has an existing Pipeline Project mining operation and processing facility (DIRS 103078-BLM 1996, all), a proposed Pipeline Infiltration Project (DIRS 103081-BLM 1999, all), and a possible Pipeline Southeast Expansion Project (DIRS 103078-BLM 1996, p. 5-7) in the Crescent Valley area of Nevada through which the Carlin branch rail line would pass (see Section 8.1.2.3 and Figure 8-5). Because the Carlin corridor would pass through the general area of these projects, there could be cumulative land-use and ownership impacts that would require mitigation.

The analysis for the Carlin rail corridor represents the maximum impact; other rail corridor implementing alternatives would have smaller impacts. Cumulative impacts for the mostly legal-weight truck scenario would also have smaller impacts.

Another private action that could result in cumulative impacts would be shared use of a branch rail line that DOE constructed and operated to transport spent nuclear fuel and high-level radioactive waste to the Yucca Mountain Repository by others (for example, mine operators, private freight shippers) because of the increased rail traffic. Because predicting the increase in rail traffic is not possible at this time, this analysis cannot estimate the cumulative impacts. There could be some added impacts to all the resource areas beyond those evaluated for the Proposed Action in Chapter 6, but there could also be benefits from the improved economic potential for resource development in interior areas of Nevada as well as greater economic development potential for nearby communities. DOE would have to consider these impacts in any decision it made to allow shared use of the branch rail line.

One Federal action and one private action could lead to cumulative impacts with the construction and operation of the Caliente intermodal transfer station. DOE has specified the Caliente site as one of four possible locations for the construction and operation of an intermodal transfer station for the shipment of low-level radioactive waste to the Nevada Test Site (DIRS 103225-DOE 1998, pp. 2-4 to 2-12). In addition, a commercial venture planned by Apex Bulk Commodities for the Caliente site would construct an intermodal transfer station for the transport of copper concentrate. Figure 8-6 shows a possible layout plan for these intermodal transfer stations at Caliente. Section 8.1 provides more information on the potential DOE and Apex intermodal transfer stations. The following sections describe the potential cumulative impact analysis at the Caliente site from the construction and operation of an intermodal transfer station to support the proposed Yucca Mountain Repository, coupled with an intermodal transfer station for shipment of low-level radioactive waste to the Nevada Test Site and an intermodal transfer station proposed by Apex Bulk Commodities.

8.4.2.1 Land Use and Ownership

Chapter 6, Section 6.1.2.1, discusses reasonably foreseeable actions along the rail corridors and heavy-haul truck routes as they would apply to the Proposed Action. The differences in Module 1 and Module 2 in comparison to the Proposed Action are discussed below.

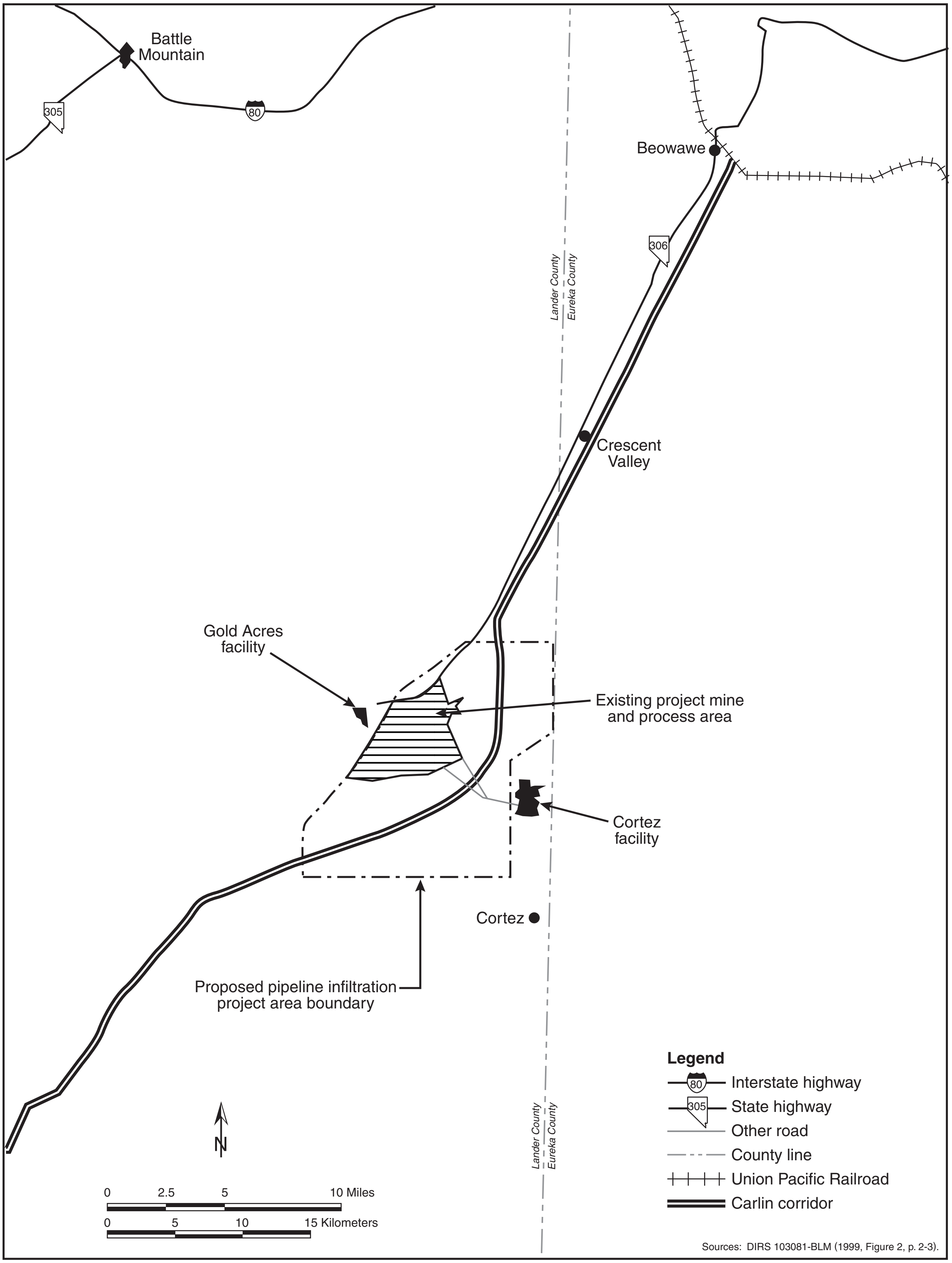

Figure 8-5. Cortez Gold Mine existing pipeline project and proposed pipeline infiltration project.

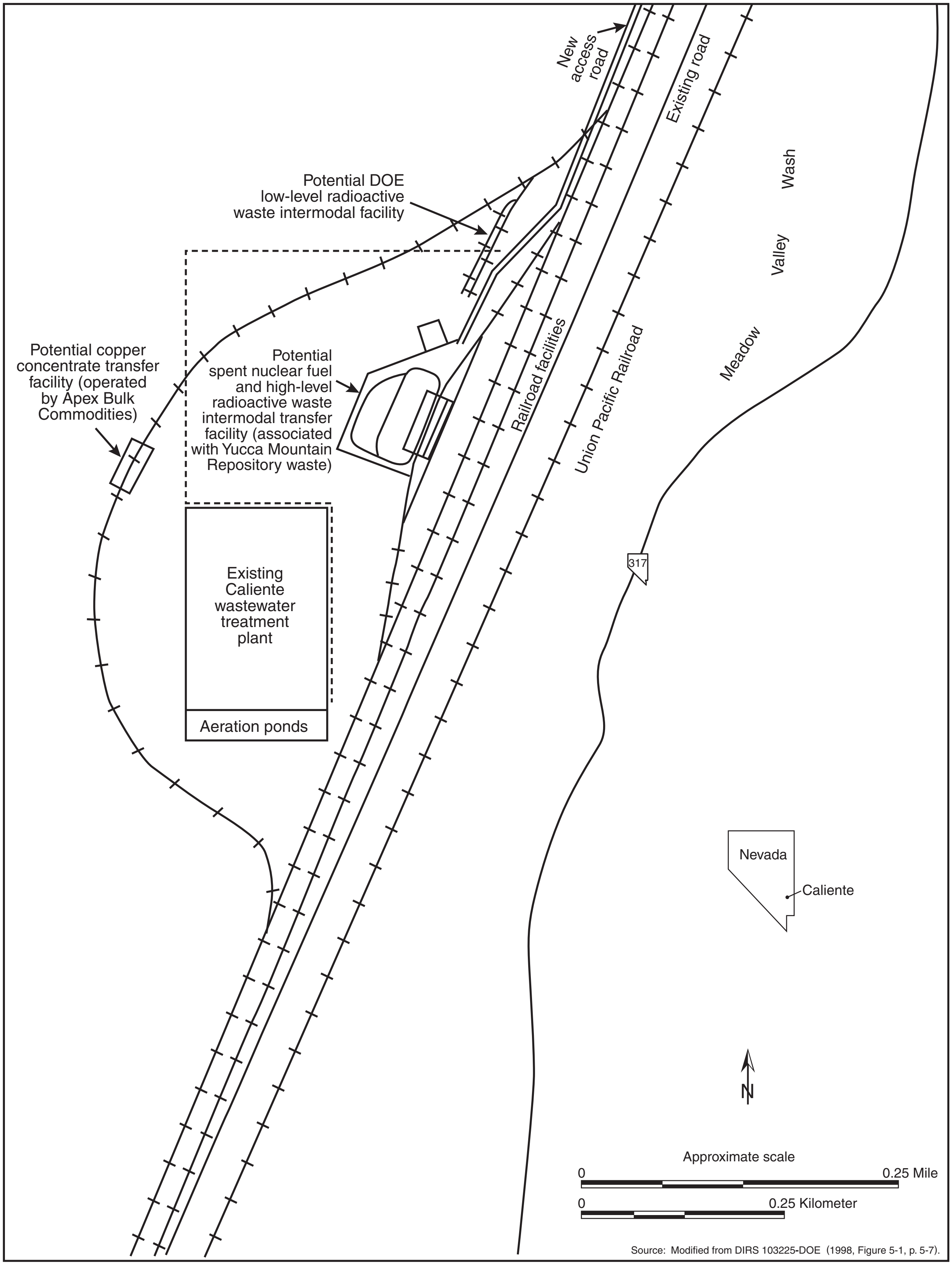

Figure 8-6. Potential locations of intermodal transfer stations at Caliente.

As discussed in Chapter 6, Section 6.3.2.1 there are currently 20 new electric generating plants proposed for the State of Nevada. Of these, 13 are proposed for Clark County in southern Nevada. Currently, plant details are not readily available for a detailed evaluation. However, should these plants be constructed, the rights-of-way necessary for transmission lines and/or natural gas supply lines will most likely be constructed on Bureau of Land Management lands. This would increase the amount of public lands in Nevada that would not be available to other users. Actual impacts associated with the rights-of-way, especially to the candidate rail corridors, would be similar to existing rights-of-way discussed in Section 6.3.2.1.

Section 6.3 of Chapter 6 and Section J.3.1.1 of Appendix J also discuss potential land use and ownership conflicts along candidate rail corridors that could result from the Proposed Action. These include potential conflicts with land areas on the Nellis Air Force Range, Timbisha Shoshone trust land parcel near Scottys Junction, Nevada, planned Ivanpah Valley regional airport, and wilderness study areas. If DOE decided to construct and operate a branch rail line in a rail corridor, it would avoid or mitigate any associated land use and ownership conflicts to implement the Proposed Action. However, additional conflicts associated with continued use of affected land areas could occur due to shipping operations being extended for 14 years beyond that of the Proposed Action.

The land required for the DOE low-level radioactive waste and Apex intermodal transfer stations would add to the approximately 0.21 square kilometer (50 acres) of property that would be required for the intermodal transfer station that would support the proposed Yucca Mountain Repository. The rail spur and facility for the low-level radioactive waste intermodal transfer station would disturb approximately 0.02 square kilometer (5 acres) of land. The Apex transfer facility would be in a building about 90 by 30 meters (300 by 100 feet). In addition, Apex would have a truck maintenance facility in a building about 30 by 18 meters (100 by 60 feet) that it could share with the low-level radioactive waste intermodal facility. The incremental impacts resulting from the changes in land use associated with the three intermodal transfer stations would not result in a substantial cumulative impact.

In addition to the cumulative changes in land use and ownership, DOE considered potential conflicts with plans and policies issued by various government entities along the alternative transportation corridors. In particular, DOE reviewed the Las Vegas 2020 Master Plan (DIRS 157274-City of Las Vegas 2001, all) and various other planning documents, including master plans for the Cities of Caliente (DIRS 157312-Sweetwater and Anderson 1992, all) and Alamo (DIRS 157275-Intertech and Sweetwater 1990, all), and the Lander County Revised Policy for Federally Administered Lands (DIRS 157310-Lander County 1999, all). The Las Vegas Master Plan provides broad policy direction for future land use decisions and related aspects in the City of Las Vegas through 2020. While the Alamo plan deals primarily with zoning issues, the Caliente plan discusses actions for dealing with potential population growth generated by the construction and operation of a repository at Yucca Mountain. The Caliente document generally expresses a need to annex lands that are contiguous to and south of the City in Meadow Valley Wash. The Caliente Intermodal Transfer Facility would be in Meadow Valley Wash (see Chapter 6, Figure 6-17). In general, local government policy indicates a goal of minimizing the conversion of private lands for public use. The transportation corridors and routes described in the EIS, particularly the rail corridors, were developed to minimize impacts to private lands. Section 6.3.2 discusses the amount of private land encountered along the rail corridors and a minimum-to-maximum range for each corridor, including variations and options. However, definitive information is not available on specific tracts of land that could be required for a specific transportation mode or route. Once DOE selected a transportation mode and a specific transportation corridor, more definitive information could be developed on potential conflicts with land uses and various agency plans and policies and, ultimately, the mitigation measures that could be needed to resolve conflicts and impacts on a given area.

8.4.2.2 Air Quality

Air quality cumulative impacts during construction of three intermodal transfer stations—one for intermodal transfers of casks containing spent nuclear fuel and high-level radioactive waste, one for intermodal transfers of low-level radioactive waste shipments to the Nevada Test Site, and one for intermodal transfers of Apex copper concentrate—would not be expected to occur since construction activities would likely occur at different times. The area in which the construction would occur is in attainment of the National Ambient Air Quality Standards and is outside of the Las Vegas Valley particulate matter (PM_{10}) and carbon monoxide nonattainment areas. Even if construction for all three intermodal transfer stations occurred concurrently, administrative controls would be implemented to prevent an adverse impact from collective emissions and dust-generating activities.

Emissions from all sources would be less than applicable standards for repository activities. Emissions would also be below established standards for a mostly legal-weight truck transportation scenario. For a mostly rail scenario, criteria pollutants would be emitted during earthmoving operations for branch rail line or intermodal transfer station and highway upgrade construction projects. Cumulative impacts would be greatest for activities occurring in the Las Vegas air basin, which is currently in nonattainment for particulate matter (PM_{10}) and carbon monoxide. For rail implementing alternatives, emissions into the Las Vegas air basin would exceed emission standards only for construction of a Valley Modified branch rail line. Emission standards could be exceeded by up to 90 percent for PM_{10} and up to 60 percent for carbon monoxide. Emissions from upgrading highways for a Caliente/Las Vegas heavy-haul truck route could also exceed standards for the Las Vegas air basin. PM_{10} emissions could slightly exceed the standard and carbon monoxide emissions could exceed the standard by 10 percent. All other activities would not cause emissions that exceeded emission standards.

During operations, there would be approximately one or two repository rail shipments and as many as 11 associated heavy-haul trucks a week, an average of about three trains and seven trucks a day for DOE low-level radioactive waste shipments, and one truck an hour for the Apex copper concentrate transport. At present, an average of one train an hour and light highway traffic travels through Caliente. The incremental increase in air pollutants from rail and highway traffic resulting from the three actions would cause slight, temporary increases in pollutants, but would not exceed Federal standards (Chapter 6, Section 6.3.2; DIRS 103225-DOE 1998, pp. 4-13, 5-4, and 5-8). Criteria pollutants released during routine operations of the intermodal transfer stations would include nitrogen dioxide, sulfur dioxide, carbon monoxide, and particulate matter. DOE expects these emissions would also be well within Federal standards.

8.4.2.3 Hydrology

Surface Water

Mitigation measures used during the construction of the intermodal transfer stations would minimize surface-water impacts. Floodplain impacts probably would occur if DOE selected the Caliente intermodal transfer station (see Appendix L). If that location was selected, DOE would conduct a detailed floodplain/wetland assessment and integrate good construction practices to minimize impacts. Construction probably would involve some permanent drainage alterations. Runoff rates would differ from natural or existing terrain but, given the relatively small size of the area, there would be little effect on overall runoff quantities for the area (Chapter 6, Section 6.3.3.1; DIRS 103225-DOE 1998, pp. 4-13 and 5-8). DOE expects very small impacts to surface waters during the construction and operation of the stations.

Groundwater

Construction activities for the intermodal transfer stations would disturb and loosen the ground for some time, which could result in higher infiltration rates. However, these activities and their resultant short-term impacts probably would occur at different times for the three stations. The relatively small sizes of the three facilities would minimize changes in groundwater infiltration rates during operations. Potential sources of contamination would include one to three diesel fuel tanks for the standby generators and heavy equipment for all three stations. The small overall water demand could be met by installing wells or by existing water distribution systems. In addition, the operation of the Apex copper concentrate and DOE low-level radioactive waste intermodal transfer station would only overlap with the beginning years of spent nuclear fuel and high-level radioactive waste shipment to the proposed Yucca Mountain Repository.

8.4.2.4 Biological Resources and Soils

The proposed locations of the intermodal transfer stations are in an irrigated pasture area that is partly wetland. However, because the area was modified as pasture and the native habitat has been degraded, cumulative impacts to biological resources would be low. Construction activities could lead to soil erosion. Water would be applied to suppress dust and compact soil. The operation of the stations would have small cumulative impacts on soils. Erosion damage control would be performed as necessary throughout the operational periods.

8.4.2.5 Cultural Resources

Cumulative impacts could occur to archaeological, historic, and traditional Native American cultural sites from the construction of the intermodal transfer stations. Cultural resource surveys of a portion of the Meadow Wash Area have identified two archaeological sites in the vicinity of the proposed Caliente DOE low-level radioactive waste intermodal site (DIRS 103225-DOE 1998, p. 4-13). Neither site falls within the proposed intermodal transfer station areas. However, Native American consultants have identified these archaeological sites as having significant cultural values for present-day Native American tribes, and construction and operation of the intermodal transfer station at this location could create a cumulative impact to these cultural values. DOE would perform ethnographic studies and archaeological surveys during the engineering design phases and before construction to identify these impacts and address their mitigation.

Impacts to cultural resources could occur along each of the candidate rail corridors where site file and literature searches have indicated a potential for archaeological, historic, and traditional cultural properties (see Chapter 3, Section 3.2.2.1.5). Some impacts to these resources could be cumulative, such the intersection of the National Historic Pony Express Trail by variations of the Carlin Corridor or the construction and operation of a branch rail line in Crescent Valley along the Carlin Corridor, where Native Americans believe that operations at the Cortez Mine have already had an impact on a Native American cemetery. After determining the mode of transportation and the preferred routing, DOE would undertake archaeological field studies and ethnographic evaluations of the corridor to identify further potential impacts and possible mitigative actions to reduce the effects of those impacts.

Some impacts associated with the use of existing highways could be cumulative, depending on the route selected. For example, Native American consultants have identified several places or areas along some of the highways that have cultural significance to regional tribes (see Chapter 3, Section 3.2.2.2.5). Heavy-haul truck traffic could have a cumulative adverse effect on the Goldfield National Register Historic District, although the potential for specific impacts to buildings in the historic district has yet to be fully evaluated. As with other potential components of the Nevada transportation scenario, DOE would complete additional archaeological, historical and ethnographic studies during the engineering design phase to identify and evaluate these types of potential impacts.

8.4.2.6 Socioeconomics

Employment levels for operation of the repository, Apex, and DOE low-level radioactive waste intermodal transfer stations would be 66, 25, and 14 employees, respectively (Chapter 6 and Section 8.1.2.2). Employment associated with the repository and low-level radioactive waste intermodal transfer stations includes operations personnel and truck drivers. Concurrent operations for all three stations would occur over a portion of the entire 24- or 38-year shipping period for the Proposed Action or Inventory Module 1 or 2, respectively. Employment levels would increase gradually to the maximum values listed above and then decrease gradually toward the end of emplacement activities for repository-related workers. Impacts to employment, population, personal income, Gross Regional Product, and state and local government expenditures during station operations would be small for Lincoln County (Chapter 6, Section 6.3.2.2; DIRS 103225-DOE 1998, pp. 4-14 and 5-9).

The truck traffic in the Caliente area would be increased from the three intermodal transfer stations. The small increase would have a very small impact on U.S. Highway 93, which would be used when entering and leaving the intermodal transfer station access road. U.S. 93 is currently characterized as having light traffic. The period of concurrent truck traffic from the three intermodal transfer stations would also occur only over a portion of the 24- or 38-year shipping duration for the Proposed Action or Inventory Module 1 or 2, respectively.

8.4.2.7 Occupational and Public Health and Safety

The incremental impacts resulting from an increase in radiological risk associated with the intermodal transfer stations for the repository and low-level radioactive waste shipments at Caliente would not result in a substantial cumulative impact. The estimated total collective worker dose from the entire DOE low-level radioactive waste intermodal shipping campaign, including transportation impacts, would be about 4.21 person-rem (DIRS 103225-DOE 1998, p. 4-10). This dose, added to the total repository intermodal transfer station and rail and heavy-haul truck shipments worker dose of about 2,200 to 3,300 person-rem for the Caliente intermodal transfer station for Inventory Module 1 or 2 (Appendix J, Table J-59) would be an increase of less than 1 percent. The population dose associated with low-level radioactive waste shipments by truck from the Caliente intermodal transfer station would be 7.55 person-rem for the entire shipping campaign (DIRS 103225-DOE 1998, Table C-11, p. C-23). This dose, added to the dose from shipments in Nevada that use heavy-haul trucks of about 600 person-rem over 38 years, would increase the population dose and associated health effects by less than 1 percent.

In addition to incremental impacts resulting from increases in radiological risk, there would be increments in nonradiological impacts of transportation in Nevada that are not included in the national impacts of transporting spent nuclear fuel and high-level radioactive waste to a Yucca Mountain Repository. These increases would arise from 14 additional years of operating a branch rail line or of maintaining highways for use by heavy-haul trucks and operating an intermodal transfer station. The increments in nonradiological impacts for operation of a branch rail line would include increased traffic fatalities from worker commuting and the transportation of spent nuclear fuel and high-level radioactive waste, as well as repository materials. The increases would range from 0.45 to 1.1 fatalities (see Tables 6-78, 6-79, 6-85, 6-86, 6-93, 6-94, J-61, J-62, and J-63).

8.4.2.8 Noise

There would be an increase in noise levels at Caliente from any of the three candidate intermodal transfer station sites and the associated train switching operations and truck traffic. Noise levels would increase during daytime and night hours for rail activities and during daytime hours for truck shipment activities associated with the repository heavy-haul trucks and the DOE low-level radioactive waste trucks. Apex truck shipments would occur once an hour, 24 hours a day. Noise associated with railcar shipments would occur as the railcars were uncoupled from trains and transferred in and out of the stations, which could occur during the day or night. Elevated noise levels would occur during loading and unloading operations and briefly as trucks passed on the highway. Trucks would not travel through Caliente for shipments to either Yucca Mountain or the Nevada Test Site. Overall, the elevation of noise levels associated with rail and truck activity near a level that would cause concern would be unlikely. In addition, due to the location of the intermodal transfer stations in an uninhabited canyon area, noise impacts from rail and truck loading and unloading would be low. Cumulative effects would also be limited because operations at the DOE low-level radioactive waste and Apex intermodal transfer stations would overlap only a portion of the shipping campaign associated with the proposed repository.

Future development of the Timbisha Shoshone Trust Lands parcel near Scottys Junction could result in additional impacts. Residences and commercial ventures located near the transportation corridor on this parcel (the Bonnie Claire variation of the Caliente and Carlin rail corridors) could encounter noise levels that would not exceed 90 dB at 15 meters (49 feet) from the route.

8.4.2.9 Aesthetics

Chapter 6, Section 6.1.2.9 discusses direct impacts from the candidate rail corridors and heavy-haul truck routes. Section 6.3.2 discusses indirect visual impacts as they could affect land use along the rail corridors.

The alteration of the landscape immediately surrounding the Bureau of Land Management Class II lands [within about 8 kilometers (5 miles) of the Kershaw-Ryan State Park] could exceed the Class II objective. In addition, the Wilson Pass Option in the Jean Corridor passes through Class II lands [55 kilometers (34 miles)] in the vicinity of Wilson Pass in the Spring Mountains. Class II designation by the Bureau of Land Management could require retention of the existing character of the landscape. However, the area proposed for the Caliente intermodal transfer station has been classified as Class III, which would require partial retention of the existing character of the landscape. The intermodal facilities would not greatly alter the landscape more than the current passing trains and sewage treatment operations. The Class II lands of the Wilson Pass Option would require retention of the existing character of the landscape. Public exposure would be limited due to obstruction by natural vegetation. Therefore, visual impacts would be very small (DIRS 103225-DOE 1998, pp. 4-12 and 5-8).

8.4.2.10 Utilities, Energy, and Materials

Electric power lines with adequate capacity are available near the site. Electric power, water supply, and sewage disposal facilities are currently provided to the sewage treatment facility near the proposed location of the intermodal transfer stations (DIRS 103225-DOE 1998, p. 4-12). Therefore, cumulative impacts to utilities would be small. The quantities of concrete, asphalt, and steel needed to build the intermodal facilities (associated mostly with the repository intermodal transfer station) would be unlikely to affect the regional supply system.

8.4.2.11 Management of Intermodal Transfer Station-Generated Waste and Hazardous Materials

The expected quantities of sanitary waste, small amounts of hazardous waste, and low-level radioactive waste associated with radiological surveys would be unlikely to have large impacts to landfill, treatment, and disposal facilities available for use by this site. Therefore, cumulative impacts for waste management would be small. Only limited quantities of hazardous materials would be needed for station operations, and DOE does not expect these needs to affect the regional supply system (DIRS 103225-DOE 1998, pp. 4-12, 4-13, and 5-8).

8.4.2.12 Environmental Justice

Because there would be no large cumulative impacts to human health and safety from the construction or operation of the intermodal transfer stations, there would be no disproportionately high and adverse impacts to minority and low-income populations. The absence of large cumulative environmental impacts for the general population means that there would be no disproportionately high and adverse environmental impacts for the minority or low-income communities. An evaluation of subsistence lifestyles and cultural values confirms these general conclusions. The foregoing conclusions and evaluations and the commitment by DOE to ensure minimal impacts to cultural resources show that construction and operation of the intermodal transfer stations would not be expected to cause or contribute to disproportionately high and adverse impacts to Native Americans (DIRS 103225-DOE 1998; pp. 4-14 and 5-9).

8.5 Cumulative Manufacturing Impacts

This section describes potential cumulative environmental impacts from the manufacturing of the repository components required to emplace Inventory Module 1 or 2 in the proposed Yucca Mountain Repository. No adverse cumulative impacts from other Federal, non-Federal, or private actions have been identified because no actions have been identified that, when combined with the Proposed Action or Inventory Module 1 or 2, would exceed the capacity of existing manufacturing facilities.

The overall approach and analytical methods and the baseline data used for the evaluation of cumulative manufacturing impacts for Inventory Module 1 or 2 were the same as those discussed in Chapter 4, Section 4.1.15 for the Proposed Action. The evaluation focused on ways in which the manufacturing of the repository components could affect environmental resources at a representative manufacturing site and potential impacts to material sources and supplies.

Table 8-59 lists the total number of repository components required for the Proposed Action and Inventory Modules 1 and 2. As listed, the total number would increase by approximately 30 to 50 percent for Modules 1 and 2 in comparison to the Proposed Action depending on the operating mode and packaging scenario. The highest total number of repository components would be for Module 2, assuming the lower-temperature operating mode using derated waste packages, and this was the number used in the cumulative impact analysis.

Based on the total number of components that would be required over a 38-year period for Inventory Module 1 or 2, the annual manufacturing rate would remain the same as that for the Proposed Action.

Based on the number of drip shields required over a 12-year period for Inventory Module 1 or 2, the annual manufacturing rate would increase about 30 percent over that for the Proposed Action 10-year drip shield manufacturing period.

Thus, the annual Module 1 or 2 impacts for air quality, socioeconomics, material use, and waste generation would be as much as 30 percent higher than those for drip shield manufacturing discussed in Chapter 4, Section 4.1.15 for the Proposed Action, and these impacts would continue for 12 years rather than the 10 years for the Proposed Action. The total number of worker injuries and illness or fatalities would increase in proportion to the increase in components manufactured. The potential number of injuries and illnesses over the entire 50-year period for Module 1 or 2 would be from 930 to 1,300 and the estimated number of fatalities would be 0.44 to 0.63 (that is, no expected fatalities), depending on the operating mode and packaging scenario. As for the Proposed Action, there would be few or no impacts on other resources because existing manufacturing facilities would meet the projected manufacturing needs and new construction would not be necessary and environmental justice impacts (that is, disproportionately high and adverse impacts to minority or low-income populations) would be unlikely.

Table 8-59. Number of offsite-manufactured components required for the Proposed Action and Inventory Modules 1 and 2.

		Operating mode/packaging scenario								
		Proposed Action			Module 1			Module 2		
		UC	C	UC/C[a]	UC	C	UC/C[a]	UC	C	UC/C[a]
Component	Description	HT		LT	HT		LT	HT		LT
Disposal containers	Containers for disposal of SNF[a] and HLW[a]	11,300	11,300	11,300 - 16,900	16,650	16,650	16,650 - 25,350	17,250	17,250	17,250 - 26,000
Rail shipping casks or overpacks	Storage and shipment of SNF and HLW	0	120	0 - 120	0	152	0 - 197	0	157	0 - 202
Legal-weight truck shipping casks	Storage and shipment of uncanistered fuel	120	8	8 - 120	227	13	13 - 227	241	13	13 - 241
Drip shields	Titanium cover for a waste package	10,500	10,500	11,300 - 15,900	15,600	15,600	16,650 - 23,400	16,300	16,300	17,250 - 24,700
Emplacement pallet	Support for emplaced waste package	11,300	11,300	11,300 - 16,900	16,650	16,650	16,650 - 25,350	17,250	17,250	17,250 - 26,000
Solar panels[b]	Photovoltaic solar panels–commercial units	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000
Dry storage cask shells[c]	Metal shell structure of storage vault for aging	0	0	0 - 4,000	0	0	0 - 4,000	0	0	0 - 4,000

a. UC = uncanistered packaging scenario; C = canistered; HT = higher-temperature operating mode; LT = lower-temperature operating mode; SNF = spent nuclear fuel; HLW = high-level radioactive waste.

b. Number of panels in use at any one time.

c. Necessary only if DOE used surface aging as part of a lower-temperature operating mode.

8.6 Summary of Cumulative Impacts

As shown throughout Chapter 8, DOE has examined many actions in the region to determine the potential for cumulative impacts. These impacts could arise from a variety of sources, including other activities in the area and reasonably foreseeable activities.

Table 8-60 summarizes cumulative impacts from all origins. Where qualitative descriptions are more meaningful, these have been included in lieu of quantitative values, although the quantitative values might be provided in this chapter. In other cases, the quantitative values have been provided to give a better representation of the potential impacts.

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Table 8-60. Summary of cumulative impacts presented in Chapter 8 (page 1 of 2).

Discipline area	Cumulative impact
Land use and ownership	About 600 square kilometers (150,000 acres) of land would be withdrawn for the repository, but land is already under Federal control. Other actions in the area would cause additional withdrawals, but some land would also be returned under the Southern Nevada Public Land Management Act. Overall, total land withdrawal analyzed in this EIS is less than 0.5 percent of total Federal lands in Nevada.
Air quality	*Nonradiological:* Emissions from all sources would be less than applicable standards for repository activities. Emissions would also be below established standards for a mostly legal-weight truck transportation scenario. For a mostly rail scenario, criteria pollutants would be emitted during earthmoving operations for branch rail line or intermodal transfer station and highway upgrade construction projects. Cumulative impacts would be greatest for activities occurring in the Las Vegas air basin, which is currently in nonattainment for particulate matter (PM_{10}) and carbon monoxide. For rail implementing alternatives, emissions into the Las Vegas air basin would exceed emission standards only for construction of a Valley Modified branch rail line. Emission standards could be exceeded by up to 90 percent for PM_{10} and up to 60 percent for carbon monoxide. Emissions from upgrading highways for a Caliente/Las Vegas heavy-haul truck route could also exceed standards for the Las Vegas air basin. PM_{10} emissions could slightly exceed the standard and carbon monoxide could exceed the standard by 10 percent. All other activities would not cause emissions that exceeded emission standards.
	Radiological: Short-term air emissions from nearby facilities would result in a dose to the maximally exposed individual of no greater than 2.5 millirem per year. Emissions from past nuclear weapons testing could have resulted in a dose of 150 millirem over the lifetime of those individuals exposed during atmospheric weapons testing. Long-term atmospheric releases from the Nevada Test Site and Beatty Low-Level Waste Facility are not expected to result in a dose greater than 0.007 millirem per year in the future.
Hydrology	*Surface Water:* Cumulative impacts on surface water quality are not expected because of the transient nature of the surface water bodies around the repository. Minor changes to runoff and infiltration rates could occur. Construction of access routes at the repository site could have minor and localized effects on several washes at Yucca Mountain. Elsewhere in Nevada, routes being considered for the movement of waste to Yucca Mountain would pass through or near floodplains and wetlands and would be assessed in more detail once a route is selected.
	Groundwater: Groundwater demands from the repository are below the perennial yield of the western two-thirds of the Jackass Flats basin. When combined with Nevada Test Site activities, the annual water withdrawal (600 acre-feet) could exceed the lowest estimate of perennial yield but would not exceed highest estimate of perennial yield. No short-term impacts to groundwater quality are expected. Long-term impacts to groundwater could be as high as 0.007 millirem per year under the conservative assumption that impacts from the Nevada Test Site and the repository overlap spatially and chronologically.
Biological resources and soils	Disturbance of desert tortoise habitat would occur. Wildlife would be displaced as a result of repository and transportation activities that used additional land in the region. Little or no loss of wetland habitat is expected. No expected impacts to any species.
Cultural resources	Adverse impacts to cultural resources are not expected. Potential for encountering cultural resources exists along transportation corridors. DOE would use practices to avoid or mitigate adverse impacts in these areas.
Socioeconomics	As many as 3,400 direct jobs during peak employment year from repository activities. Intermodal transfer station or rail line in Lincoln County could change employment estimates by 5 percent.

Table 8-60. Summary of cumulative impacts presented in Chapter 8 (page 2 of 2).

Discipline area	Cumulative impact
Occupational and public health and safety	*Nonradiological:* Repository activities, including transportation, could result in up to 37 fatalities[a] from construction to closure of the repository. *Radiological:* Radiation exposure could result in up to 32 latent cancer fatalities[a] to workers. Short-term radiation exposure to the public could result in up to 5 latent cancer fatalities[a] in the population. Short-term radiation exposure to the maximally exposed individual could cause an increased cancer risk of about 1.2×10^{-6}. Emissions from past nuclear weapons testing could have caused an increased risk of about 7.5×10^{-5} for affected individuals. Long-term releases from the repository and other actions in the area could cause an increased risk of fatal cancer in the future of 0.000006 over the lifetime of an exposed individual.
Noise	Noise levels would be transient and would not be expected to cause adverse impacts for repository operation. Future development of the Timbisha Shoshone Trust Lands near Scottys Junction could result in residents of that parcel being subjected to transient noise from a candidate rail corridor through the parcel.
Aesthetics	Placement of exhaust stacks on top of Yucca Mountain could impact visual resources because stacks would be visible from some distance. If the stacks were equipped with beacons, the visual effect would be more noticeable at night. Disturbed areas would be likely on former Federal lands that are used for commercial and private purposes. Acquisition of private lands by the Federal Government could result in reduced aesthetics impacts and possible return of land to natural state.
Utilities, energy, materials, and site services	Peak electrical power demand would require upgrade to electrical transmission and distribution system. Other site systems and nearby suppliers of materials would be sufficient to meet repository and transportation needs. Construction of electrical generating facilities in the region surrounding the repository would increase the electrical generating capacity for the area.
Waste management	If nonradioactive, nonhazardous solid waste was disposed of at the Nevada Test Site, existing landfills would need to be expanded. Other waste types could be disposed of at nearby facilities without exceeding capacities of those facilities.
Environmental justice	No disproportionately high and adverse cumulative impacts to minority or low-income populations would occur for repository, transportation, or other activities. DOE recognizes that Native American people living in the region near Yucca Mountain have concerns about the protection of traditions and the spiritual integrity of the land that extend to the propriety of the proposed repository, and that implementing the Proposed Action would continue restrictions on access to the proposed site.

a. These values represent the maximum for each environmental resource area. Because the maximum could occur for different implementing alternatives in the various resource areas, simple addition of these maximums could overstate the impacts due to mixing of incompatible alternatives.

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Note: In an effort to ensure consistency among Yucca Mountain Project documents, DOE has altered the format of the references and some of the citations in the text in this Final EIS from those in the Draft EIS. The following list contains notes where applicable for references cited differently in the Draft EIS.

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